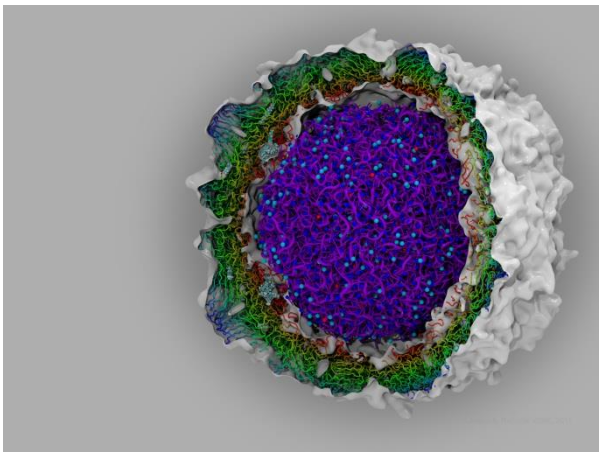
ACIL ALLEN CONSULTING

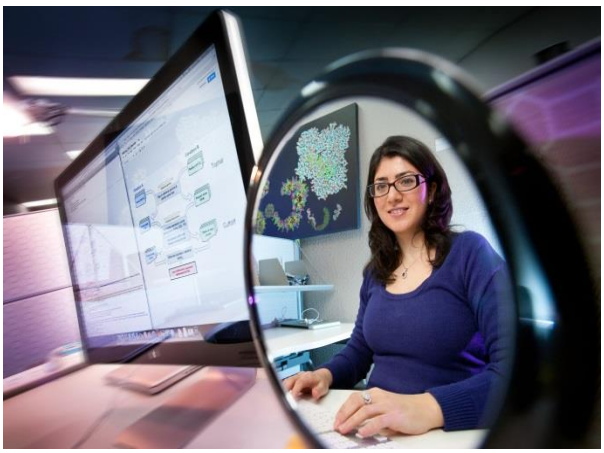
REPORT TO
THE VICTORIAN LIFE SCIENCES COMPUTATION INITIATIVE

NOVEMBER 2013

EVALUATING THE VLSCI:

A BENEFITS REALISATION ANALYSIS





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Cover photos (from top left)

1. The first 4 million atom complete virus simulation. Performed on BlueGene/P at VLSCI by Jason Roberts, Victorian Infectious Diseases Laboratory, a WHO Regional Reference Laboratory

2. Media viewing the June 2012 demonstration of the first complete 3D model of the Rhinovirus (Common cold virus) as generated on the new IBM BlueGene/Q supercomputer. Image credit: VLSCI 2011 IBM Research Collaboratory Annual Report - Flagships

3. Dr Michael Kuiper, Molecular Modelling Scientist, VLSCI, demonstrating his 3D models to LSCC staff members Dr Gayle Philip (standing), Dr Clare Sloggett and Dr Chol-Hee Jung. Image credit: Peter Casamento

4. Mahtab Mirmomeni, Masters of Computer Science, University of Melbourne, VLSCI summer intern and now employed one day a week at the IBM Research Collaboratory for Life Sciences, Melbourne. Image credit: Peter Casamento

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Glossary

AAC	ACIL Allen Consulting
ABS	Australian Bureau of Statistics
ANU	Australian National University
ARC	Australian Research Council
BVA	Bionic Vision Australia
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DBI	Department of Business and Innovation (former)
DIIRD	Department of Innovation, Industry and Regional Development (former)
DNA	Deoxyribonucleic Acid
FLOPS	Floating-point Operations Per Second
FoR	Field of Research
FTE	Full Time Equivalent Staff
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HP	Hewlett Packard
HPC	High Performance Computer
HRV	Human Rhinovirus
JIF	Journal Impact Factor
KPI	Key Performance Indicator
LSCC	Life Science Computation Centre
N/A	Not Applicable
NCI-NF	National Computational Infrastructure – National Facility
NeCTAR	National eResearch Collaboration Tools and Resources Project
NHMRC	National Health and Medical Research Council
PCF	Peak Computing Facility
PhD	Doctor of Philosophy
RAM	Random-Access Memory
RAS	Resource Allocation Scheme
SAC	Scientific Advisory Committee
Q1	Quartile 1
VLSCI	Victorian Life Sciences Computation Initiative
VPAC	Victorian Partnership for Advanced Computing
3D	Three Dimensional
$A	Australian dollars

Executive summary

The Victorian Life Sciences Computation Initiative (VLSCI) has commissioned ACIL Allen to carry out a benefits realisation analysis of the operations of the VLSCI.

The importance of computers in life sciences research is increasingly recognised. The fact that 2013 Nobel Prize for Chemistry and the 2013 Prime Minister's Prize for Science were both awarded to scientists who used powerful computers to carry out ground breaking life sciences research is an illustration of that recognition.

The ability to access supercomputers allows researchers to apply new, data intensive, technologies such as genomics in life sciences research. It also helps to accelerate the application of research results into changes in disease detection and diagnosis, developing new drugs for treatment of illnesses and drive changes in clinical practice. All of these things will have profound impacts on the health and wellbeing of populations in Australia and around the world.

The ten key findings of our analysis are presented below.

VLSCI is the world's top life sciences research supercomputer

The VLSCI is a $50 million research infrastructure funding initiative that provides supercomputing facilities and resources to support and strengthen research in the fields of life sciences.

It is currently ranked as the 39th fastest supercomputer in the world and the second fastest in Australia. VLSCI currently has the world's fastest supercomputer that is dedicated to supporting life sciences research. It is ahead of its closest competitor by a considerable margin.

VLSCI is a powerful mechanism for supporting life sciences research

The 'package of services' provided by VLSCI, namely the access to the VLSCI's Peak Computing Facility (PCF), the researcher support provided by the Life Sciences Computation Centre (LSCC) and the outreach function delivered by those two groups provides a powerful and globally unique mechanism for supporting life sciences research. VLSCI allows more ambitious research to be undertaken with great speed and efficiency.

It is the combination of access to the world's best life sciences dedicated supercomputer and the support services provided by staff at the PCF and the LSCC that makes the VLSCI such a unique facility in terms of its ability to add value to the research projects being supported by the facility. That added value is delivered through a number of mechanisms, including:

- the advice that the highly skilled PCF and LSCC staff can provide on the design and operation of research projects, including what software is most appropriate
- by VLSCI staff participating in (including leading) some research projects.

VLSCI enables world class research by Victorian life sciences researchers

The number of publications resulting from the research carried out using the VLSCI infrastructure is increasing over time. Importantly, the majority of the publications are in journals that have been assessed as having Journal Impact Factors (JIF) in the first quartile of journals in the life sciences field. In other words, journals judged as being in the top 25 per cent of journals in their category (see discussion in Section 3.1.3).

The high proportion of VLSCI supported research published in journals ranked in the first quartile demonstrates that that research is highly regarded globally.

VLSCI supports Victoria's strong reputation in life sciences

Victoria has an excellent reputation for life sciences research and a growing life sciences industry. The VLSCI is helping to build that reputation. The increasing number of highly rated publications arising from VLSCI-supported research and the strength of the Victoria's life sciences sector is providing the foundations for future industry growth in the State.

The fact that researchers involved with the VLSCI are beginning to be recognised through the granting of various national and international awards also supports the view that the facility is increasing the reputation of Victoria as a world-class centre for life sciences research. The recent award of the 2013 Prime Minister's Prize to Prof Terry Speed further demonstrates VLSCI's importance. Another scientist who received a national award came to Victoria after completing her doctorate overseas because of the strong reputation for life sciences research in the State.

VLSCI is highly effective at increasing collaboration.

The VLSCI is proving to be highly effective in creating and supporting collaborations. Much of the research being supported by VLSCI is by its very nature collaborative, involving the need for team members with differing skill sets such as informatics, chemistry, biology and statistics. In addition many of the structures established at the PCF and the LSCC are strongly supportive of increased collaboration. VLSCI researchers are also strongly engaged in international research.

This includes arrangements such as staff from the IBM Collaboratory working in the PCF to provide software and hardware support to researchers. In addition, there IBM staff who are active participants in research projects.

The LSCC links life sciences researchers at the University of Melbourne, La Trobe University and Monash University. The members meet every fortnight to discuss research developments and address any challenges that have arisen. Meetings are open to other life sciences researchers who want to explore potential projects.

In addition, the VLSCI's outreach activities also encourage life science researchers to engage with each other and help build collaborations across research groups.

VLSCI is delivering benefits now

VLSCI supported researchers have also been successful in attracting national grant funding to flow into Victoria. In 2011 and 2012 VLSCI researchers were awarded at least $30 million in research grants. These grant funds create jobs for Victorians and the application of work undertaken under these grants will provide future commercial opportunities and clinical applications.

Our analysis has shown that at least 36 additional jobs have been generated as a direct or indirect result of VLSCI's presence. It is possible that the cumulative number of new jobs created could be as many as 79 (and possibly more).

Training and mentoring is provided by VLSCI through their outreach program. They provide grants and scholarships to students. LSCC staff run regular seminars and workshops that provide training to students and staff (see sections 3.4.1 and 5.4).

According to the stakeholders we spoke with, the number of people with the necessary skills to support cutting edge life sciences research (such as bioinformaticians) has grown from very few to a substantial number over the last few years.

The pool of skilled people has now grown to the point that there is an observable trend of former students and researchers who received training and or support from VLSCI who now in turn beginning to provide training to the next generation of students.

VLSCI will deliver more benefits in the future

There is little doubt that some of the early benefits of the VLSCI discussed above will continue to accrue. In addition it is highly likely that there will be commercialisation opportunities that flow from the research being conducted at VLSCI. Some of these, such as improved health outcomes due to changes in clinical practice are already beginning to emerge.

The timing of some other benefits is more uncertain. We have examined four projects that were judged to have good prospects for delivering future benefits. Even if only one of these opportunities ultimately comes to fruition, there is a strong likelihood that the benefits could be considerable. In the near future, VLSCI will need to expand its efforts to engage with industry.

VLSCI needs to transition to a more sustainable future

VLSCI has made some progress towards improving its sustainability. Increased private sector involvement in, and support for, the VLSCI would undoubtedly help ensure the sustainability of the facility. However, with the exception of in kind contributions by IBM, we are not aware of any private sector contributions to the VLSCI.

The best prospects for gaining more private sector support are probably through the normal process of translating promising research results into commercial products. As discussed above, there are a number of projects that have potential promise in this regard. However, commercialisation of medical research normally takes considerable time, and private sector interest in VLSCI research outcomes is only just beginning to emerge.

VLSCI should become more national in its approach

We believe that the key to the future sustainability of VLSCI lies in its ability to transition from a largely state-based facility to one that has a national focus. In other words, to position itself as a provider of life sciences research infrastructure that supports researchers across the whole of Australia. VLSCI has already begun this transition by committing 15% of the BlueGene/Q capacity to the National Merit Allocation Scheme (NCMAS). This is the same percentage allocation of resources committed nationally by the other two major supercomputer facilities in Australia – Pawsey and NCI.

As a facility that supports cutting edge scientific research VLSCI will most likely continue to rely on public sector support to continue its operations. To improve its prospects of obtaining funds from the Victorian and Commonwealth Governments VLSCI needs to ensure its objectives are well aligned with those of these two jurisdictions and demonstrate how its activities will contribute to achieving the Victorian and Commonwealth Governments' objectives, plans and priorities.

VLSCI governance arrangements need to evolve

As the operations of VLSCI evolve and mature there is a need to review the governance arrangements for the facility. While the current arrangements have worked during the initial phase, further sustainable growth requires some changes to

position the VLSCI to become a national facility and receive Commonwealth Government support in future. This is discussed further in section 6.2.2.

1 Introduction

1.1 Background and context

The Victorian Life Sciences Computation Initiative (VLSCI) has commissioned ACIL Allen to carry out a benefits realisation analysis of the operation of the VLSCI. The purpose of the task is to identify the nature and scope of the benefits delivered as a result of the operation of the VLSCI to date, carry out an independent analysis of the user satisfaction surveys and, finally, recommend a method and tools for carrying out future evaluations of the VLSCI's activities post 2014.

1.2 Study objective and scope

The services we are to deliver for this project are shown in Box 1.

BOX 1 **SCOPE OF SERVICES**

1. For the Benefits Realisation Analysis, the supplier will deliver:

A theoretical analysis which compares how else the demands of the life sciences community could have been supported other than through the VLSCI.

A financial analysis which assesses the level of activity generated through in-kind support and budget spending by the VLSCI and attempts to evaluate the financial impact of the Initiative, using quantifiable measures of success – such as researcher grant income, staff attraction and retention, training and skills development opportunities, industry engagement and research contracts and patents and publication results.

An independent analysis of the user satisfaction surveys completed for 2011 and 2012 Annual Report submissions, to provide an objective assessment of users' perceptions and experiences in interacting with the VLSCI.

Through interviews with key, top users of the VLSCI's services, apply an independent and rigorous analysis of the project to date: how it was implemented against the Business Plans and the effectiveness of its key components – the PCF, LSCC, and Outreach.

This analysis may consider the success of the project in light of other ways the money invested in VLSCI could have been spent.

Finally, this report should identify non-financial benefits and assess the success of the initiative to date in the way it has contributed to other ways to the life science community in Victoria e.g. Where awareness-raising activities have impacted on the general level of awareness in the community of the exciting new era of computational biology.

2. For the gap analysis, the supplier will provide a summary report of findings as discovered during the benefit realisation analysis process.

3. For the Future Evaluation methodology, the supplier will provide:

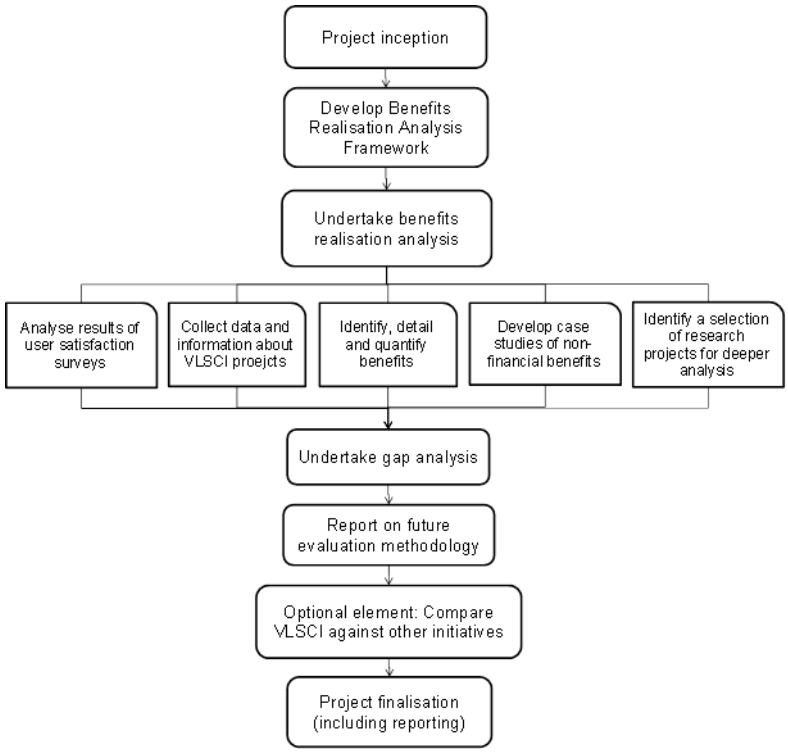
A recommended method and tools for carrying out future evaluations of all aspects of the VLSCI's activities for the purposes of informing current and future stakeholders.

SOURCE: RFQ, PAGES 3-4

1.3 Approach to the evaluation

ACIL Allen's approach to this project is illustrated in Figure 1. Key elements of the work are discussed in the sections that follow.

FIGURE 1 **PROJECT TASKS**



SOURCE: ACIL ALLEN

1.4 Benefits realisation analytical framework

There are a number of ways to define a benefit. For example, a benefit can be defined as:

> A measureable improvement resulting from change perceived as advantageous. [1]

Or as an:

> Outcome that delivers value to an organisation… when they contribute to achieving their strategic goals and objectives. [2]

1.4.1 Principles for identifying and analysing benefits

ACIL Allen adopted a set of principles to help guide the identification, classification, analysis and (where possible) valuation of benefits delivered by VLSCI.

— *Benefits are material*

— *Benefits should ideally be quantifiable*

[1] *Lean Benefits Realisation Guide*, Highways Agency, February, UK Treasury, 2013.

[2] *Benefits Realisation Guideline*, Version 1.2, NSW Finance and Services 2011, 30 June 2011

— *Benefits are stand-alone*

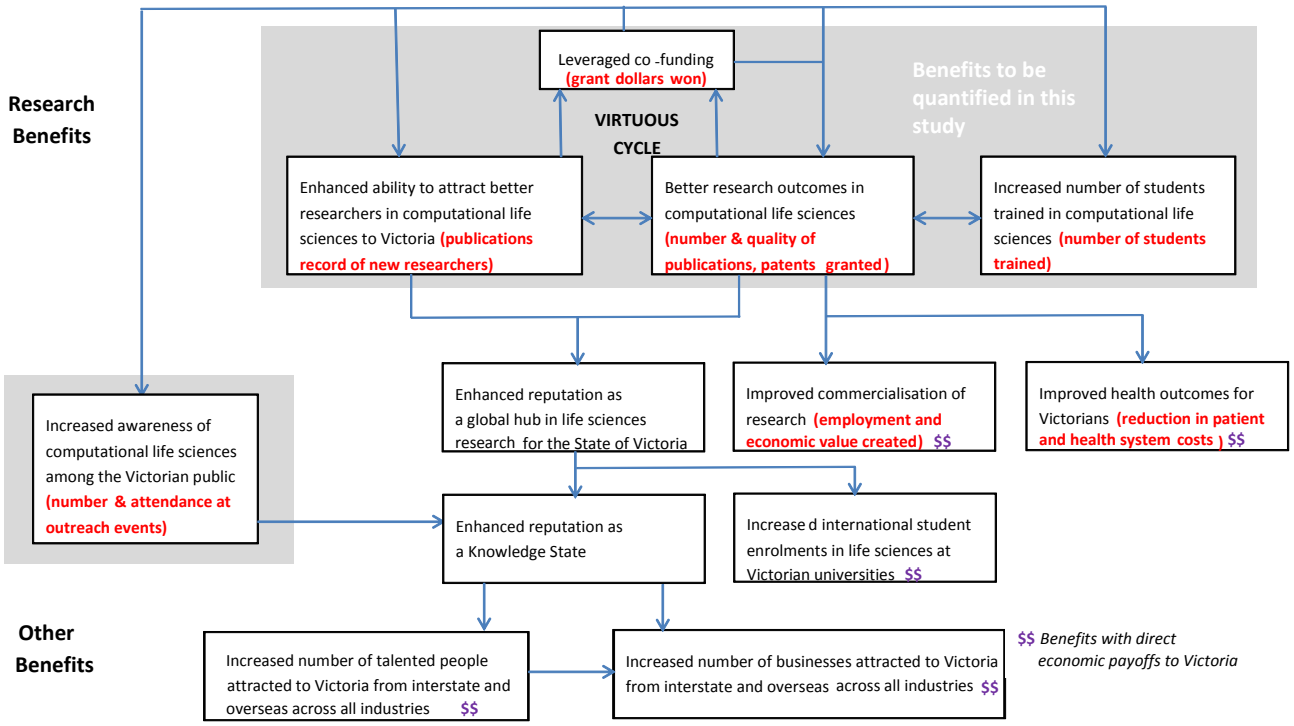
— *Benefits may have trade-offs*

— *Benefits are not counted more than once*.[3] [4]

Ideally only benefits that satisfied all the above principles would be analysed by ACIL Allen. However, various factors, such as the short time frame since the VLSCI began operating, mean that some flexibility has had to be shown in the evaluation.

The benefits delivered by the VLSCI can largely be divided into two categories. One category is benefits that are delivered relatively quickly. These include benefits such as flows of grant money to researchers, additional employment, publications and presentations, training and education, greater awareness of Victoria's capabilities in computational life sciences and an enhanced reputation for excellence in the field.

FIGURE 2 **ILLUSTRATION OF POTENTIAL VLSCI BENEFITS**



SOURCE: ACIL ALLEN

The second category of benefits is one that normally takes longer to be delivered. These are benefits that flow from the translation of research outcomes into commercial products and changes in procedures that can deliver significant direct benefits in areas such as improved public health outcomes (in relation to the prevention, detection and treatment of illnesses) and secondary benefits in terms of the creation of new or expanded businesses that bring new products to market.

[3] *Cost Benefit Analysis in Transport*, Discussion Paper; OECD, Paris, 2010

[4] *Toolkit for the Economic Evaluation of World Bank Transport Projects*, World Bank 2003, US.

The time between discovery and commercialisation is usually considerable. This is particularly the case in the field of health where the testing and approvals process for a new treatment can take several decades.

1.4.2 Measuring current VLSCI benefits

ACIL Allen sought to measure the first category of benefits, namely those that are already accruing as a result of the operations of the VLSCI. This was done through an analysis of the reports submitted by VLSCI users. Larger projects are required to report to VLSCI. As noted in the VLSCI Annual Report for 2012:

> Chief Investigators are required to submit comprehensive reports if they were allocated over 5000 service units and their project was active for the whole of 2012. [5]

Managers of relevant projects are required to complete an annual questionnaire. The questions asked of relevant VLSCI projects in 2011 and 2012 are provided in Appendix A.

ACIL Allen received a summary of the responses submitted by projects which reported in 2011 and 2012. There were 42 respondents in 2011 and 51 respondents in 2012. ACIL Allen independently analysed the responses provided by projects in order to as accurately as possible quantify the benefits stemming from VLSCI projects.[6]

To help ensure that the benefits assessment is as robust as possible, ACIL Allen also reviewed:

- Relevant VLSCI plans, strategies, annual reports, performance reports, financial reports, user reports, and other internal documentation, with the objective of demonstrating progress against the VLSCI's Key Performance Indicators (KPIs).
- Relevant reports and information from research and industry partners.
- Relevant contextual data important to understand the counterfactual analysis (e.g. historical information relating to research and research training outputs).
- Key financial and operational documents including :
  - Income – including VLSCI cash funds, in-kind contributions, other income (e.g. interest and commercial income)
  - Expenditure – salaries (including committees) and non-salary expenditure.
  - Sponsorship – including conferences and workshops that relate to individual research projects.
- Other relevant information relating to the VLSCI's funding, operations and outputs.

Estimating future benefits is, of course, much more difficult. For example, there is uncertainty not only in terms of what a particular research outcome will ultimately deliver in terms of a better public health outcomes but also in terms of when that benefit might be delivered. [7]

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[5] VLSCI. 2012, *Annual Report*, VLSCI, page 36.

[6] It should be noted that the formulation of the questions posed by VLSCI meant that some respondents provided the same data in 2011 and 2012. For example, the question requesting information on publications and presentations resulting from the VLSCI project did not specifically request "new" publications and presentations. As a result, some respondents listed the same publications and presentations in both 2011 and 2012. A similar issue occurred with the questions regarding grants and additional employment. As part of our analysis ACIL Allen sought to eliminate any duplication in reporting. While it proved possible to remove double counting in relation to grants and publications, it was not possible to fully account for any possible double counting in relation to additional employment.

[7] One of the benefits of the VLSCI is that it can accelerate the discovery process by helping academics (and firms) to better identify areas of research with greater prospects for successful outcomes.

In order to help illustrate the nature and scope of potential future benefits, ACIL Allen developed a series of case studies. The case studies were informed both by the desk top review of documents described above and by consultations with stakeholders identified by ACIL Allen. Those stakeholders included researchers, government officials, VLSCI staff and members of a range of other organisations (see Table 1).

The stakeholder consultations were also used to:

- help identify categories and types of benefits
- verify information obtained from analysis of the responses to the annual VLSCI questionnaires
- identify what, if any, alternative supercomputing facilities and resources (including overseas) researchers could potentially use in the absence of VLSCI
- review and refine projects that might be candidates for case studies
- obtain other possible sources of data for analysis.

TABLE 1 **STAKEHOLDERS CONSULTED**

Name	Affiliation	Interview date
Prof. Tony Bacic	Member, Scientific Advisory Committee (incoming Chairman), VLSCI Member, Steering Committee, VLSCI Director, Bio21 Molecular Science and Biotechnology Institute	26 September 2013
Prof. David Bowtell	Head, Cancer Genomics and Genetics Program Principal Investigator, Australian Ovarian Cancer Study Peter MacCullum Cancer Centre	24 September 2013
Matt Dummett (with Amelia King)	Director Science and Technology Policy Department of State Development, Business and Innovation (Victoria)	9 October 2013
Dr Gary Egan	Professor & Director Monash Biomedical Imaging Monash University	13 November 2013
Prof. Robin Gasser	VLSCI user (project VR0007)	25 September 2013
Dr Kathryn Holt	Research Fellow Dept Biochemistry & Molecular Biology Bio21 Institute University of Melbourne	1 November 2013
Prof. James McCluskey	Professor Microbiology and Immunology Deputy Vice Chancellor (Research) University of Melbourne	3 October 2013
Assoc. Prof Matthew Perugini	ARC Future Fellow and VLSCI user Dept of Biochemistry La Trobe University	11 November 2013
Dr Michael Sargent	M.A.Sargent & Associates Pty Ltd	3 September 2013
Torsten Seeman	Acting Head (in the absence of Andrew Lonie), LSCC	26 September 2013
Prof Robin Stanton	Deputy Chair, Steering Committee National Computation Infrastructure NCI	17 October 2013
Peter Taylor	Director, VLSCI	2 October 2013
Bruce Thorley Jason Roberts	VLSCI users (project VR0069)	25 September 2013
John Wagner	Manager and Research Staff Member IBM Collaboratory	25 September 2013

SOURCE: ACIL ALLEN CONSULTING

1.5 Report structure

The remainder of this report is structured as follows:

- Section 2 reviews the objectives, governance, facilities and operations of the VLSCI. This section also examines potential alternative supercomputing facilities.
- Section 3 examines the current benefits being delivered by the VLSCI.
- Section 4 considers the potential future benefits of VLSCI.
- Section 5 evaluates the performance of the VLSCI to date.
- Section 6 examines the way forward. It discusses possible changes to the future objectives and operations of the VLSCI and what additional data might be helpful in measuring and evaluating the future performance of the VLSCI against those objectives.

2 VLSCI

Victoria's biotechnology research sector is world class and the State enjoys a strong international reputation as a location for biotechnology. *Victoria's Technology Plan for the Future - Biotechnology* seeks to consolidate that leadership, and position the sector for the next stage of growth and ensure that it remains competitive in a challenging global environment. The Plan confirms the State's goal to be a leader in life sciences research. It notes that:

> Biotechnology is a vitally important Victorian industry and an area of competitive advantage for the State, with the potential to make a major contribution to future economic growth and increased productivity. Biotechnology is an enabling technology that is already generating substantial benefits in many areas. They include new treatments for diseases and injuries, more sustainable and productive industrial and agricultural processes, and better environmental management practices. [8]

The VLSCI is identified as part of Victoria's world-class science research infrastructure and capability in the field of biotechnology that the Plan is intended to maintain.

The Grant Agreement between the University of Melbourne and the Victorian Government to establish the VLSCI was signed on 10 June 2008. The Agreement sets three key targets:

- the cumulative value of the contributions to the VLSCI to reach $100m by 30 June 2013
- the peak computing facility (PCF) to rank in the top 5 facilities for life sciences research precincts internationally, with the target to be the top life sciences PCF by 30 June 2013
- the effective annual full-time equivalent staff resources supported by the VLSCI to reach 30 full-time equivalents by 30 June 2013.[9]

2.1 VLSCI Vision

The VLSCI is a $50 million research infrastructure funding initiative that provides supercomputing facilities and resources to support and strengthen research in the fields of life sciences. The 2013-2014 VLSCI Business Plan describes its vision as bringing about:

> …a dramatic shift in Victorian life sciences research leading to significant achievements and outcomes in medical, health, biological and related sciences.[10]

2.2 VLSCI aims and objectives

The VLSCI Business Plan for 2013-2014 states that the aims of the VLSCI are to:

- provide a world-class computational service that will support the transformation of life sciences research in Victoria
- provide a leading computing facility with the capability to address much larger life sciences research problems than currently being addressed in Australia

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[8] *Victoria's Technology Plan for the Future – Biotechnology*, Department of Business and Innovation. 2011.

[9] VLSCI Business Plan 2010-2013, January 2010

[10] VLSCI Business Plan 2013 – 2014, VLSCI, 2013.

- facilitate greater research collaboration within the state, nation-wide and internationally
- develop skills in computational biology, bioinformatics, advanced simulation and modelling, data management and more generally the application of advanced computing in life sciences
- support industry development in Victoria, through the uptake of computational research in life sciences.

The VLSCI website identifies six objectives that guide how its support is delivered to the Victorian life sciences community. Those objectives are to:

- Achieve a strong user base extending throughout Victorian research institutions and beyond into national and international collaborations.
- Enable excellent research outputs (of both quality and quantity).
- Embed the operation of the completed facility.
- Employ at least 30 expert staff on the program.
- Plan for sustainability beyond the life of the initial contract.
- Identify and move into other research areas.[11]

The presence of VLSCI expands the computation capacity of Victoria, and provides access for universities, researchers and students to undertake cutting-edge research in computational biology, bioinformatics and computational imaging. This enables researchers to study a broader range of subject areas in more depth and obtain results more quickly than could have been done in the absence of the VLSCI's supercomputing facilities.

It also enables researchers to more effectively transform basic or pure research into outcomes that can benefit the social and economic well-being of the Victorian community. This has the potential to attract new industries, business and investment to Victoria and, in turn, boost the economic vibrancy and competitiveness of the State.

As noted above, the VLSCI is focussed on supporting research in fields related to 'life sciences'. Generally only research classified as life sciences (as determined by the Fields of Research codes of the Australian and New Zealand Standard Research Classification) is eligible for support from VLSCI. Table 2 lists the Fields of Research (FoR) that are used by to determine whether a research project is eligible for support.

To ensure a broad range of research activity is captured, VLSCI also offers research support to projects that can demonstrate a direct or substantial linkage to life sciences. This means that researchers typically working outside the research areas in Table 2 are eligible for support if the primary application or beneficiary of the research is within the field of life sciences.

[11] Retrieved October 2013, from VLSCI: http://www.vlsci.org.au/page/about

TABLE 2 **DEFINITION OF LIFE SCIENCES**

2-Digit FoR	4-Digit FoR
06	(all) Biological Sciences
07	(all) Agricultural and Veterinary Sciences
10	The following FoRs: — 1001 Agricultural Biotechnology — 1002 Environmental Biotechnology — 1003 Industrial Biotechnology — 1004 Medical Biotechnology — 100703 Nanobiotechnology — 100709 Nanomedicine
11	(all) Medical and Health Sciences

SOURCE: VLSCI 2013 'LIFE SCIENCE DEFINED', HTTP://WWW.VLSCI.ORG.AU/PAGE/LIFE-SCIENCES-DEFINED

It is important to note that an application to the VLSCI's Resource Allocation Committee to use the facility's computing infrastructure can only be made by Victorian researchers. Thus it is only possible for researchers outside the state to access the VLSCI facilities if they have a research partner based in Victoria.

2.3 Governance and operational structure

VLSCI was established as the result of an agreement between the Victorian Government, the University of Melbourne and IBM. Its governance and organisational structures reflect the diversity of its stakeholder base.

A number of committees share responsibility for the governance of VLSCI. These committees (and their roles) are listed in Table 3. The committees generally meet between one and four times per year.

The day-to-day operations of VLSCI are overseen by a dedicated Directorate. The Directorate is led by a VLSCI Director with support from a Business Manager, Executive and Administrative Officers. The Directorate currently has six staff based in offices in Carlton.

TABLE 3 **VLSCI'S GOVERNANCE COMMITTEES**

Committee	Description
LSCC Advisory Committee	The Life Sciences Computation Centre (LSCC) Advisory Committee is a superset of the LSCC Executive with the addition of a member from both the VLSCI Steering and Scientific Advisory Committees. This Committee makes recommendations to the Director of VLSCI on how LSCC resources (research and resources) should be allocated.
LSCC Executive Committee	The LSCC Executive is comprised of the LSCC Head, the VLSCI Director and the current LSCC Theme Leaders. This guarantees representation for all hub institutions, as each hosts at least one Theme Leader. The role of the Executive is to provide tactical research management of the LSCC.
PCF Advisory Committee	The Peak Computing Facility (PCF) Advisory Committee advises the PCF Manager on the operations and performance of the PCF. Its membership reflects the major users of the PCF.
Resource Allocation Scheme Committee	The Resource Allocation Scheme Committee (RAS Committee) deliberates on applications for access to the Peak Computing Facility. This is a merit-based system. The Committee meets twice per year to allocate resources on a rolling 12 month basis.
Scientific Advisory Committee	The Scientific Advisory Committee (SAC) provides advice to the Director on the appropriate use of the LSCC and the PCF. It also considers opportunities to initiate new research areas and collaborations to take advantage of these resources.
Steering Committee	The Steering Committee advises the University regarding the overall Initiative, especially the strategies, policies and performance of the VLSCI. The University will consider changing the role of the Steering Committee if other research organisations make substantial commitments to the VLSCI in the future. In this situation, the VLSCI would become a joint venture with responsibilities divided between the members of the committee who would be representative of the organisations making commitments to the initiative.
University Reference Group	The University of Melbourne formed the VLSCI Steering Group in August 2008 to direct the development of the VLSCI. With the appointment of the VLSCI Steering Committee the group was transformed into a University Reference Group to provide advice to the University on recommendations of the Steering Committee. The group reviews the University's responsibilities in the Grant Agreement particularly the financial model and risk management plan.
University – Victorian Government VLSCI Liaison	Representatives of the University of Melbourne and the Victorian Government regularly liaise to review progress with the implementation of the VLSCI Business Plan. The Initiative is overseen by the Victorian Government Department of State Development, Business and Innovation (formerly DBI and DIIRD).

SOURCE: VLSCI 2013 'GOVERNANCE COMMITTEES', http://www.vlsci.org.au/page/our-people?q=page/governance-committees

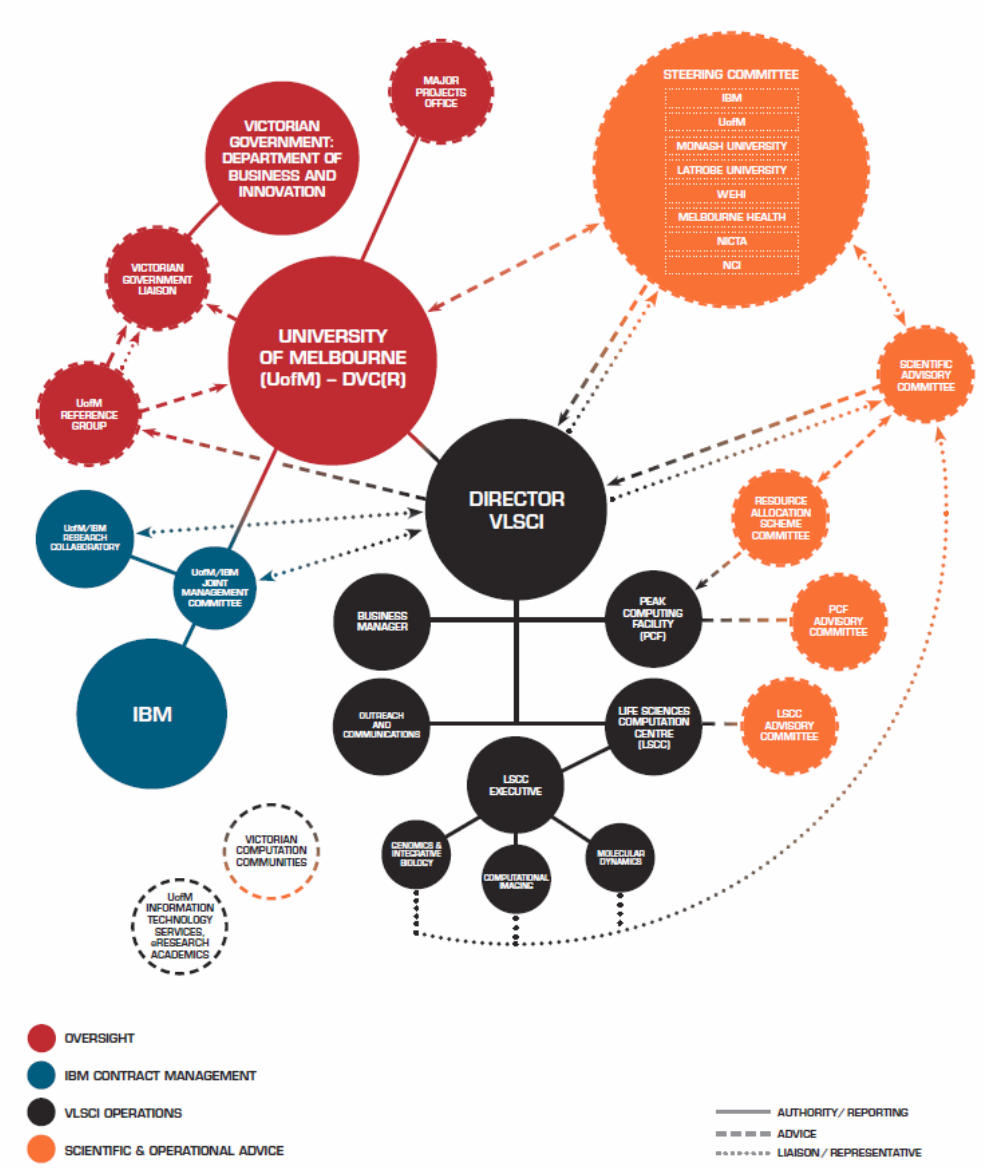
The Peak Computing Facility (PCF) is managed through offices in Carlton. It has dedicated staff who can assist researchers with a range of technical software and hardware problems. Currently 11 staff work directly for the PCF, three of whom are supplied by IBM as part of the agreement with the University of Melbourne.

The Life Sciences Computation Centre (LSCC) is a collaborative arrangement between the University of Melbourne, Monash University and La Trobe University. The LSCC has three hubs in the research precincts of Central (Parkville), South-Eastern (Clayton) and Northern (Bundoora). The LSCC offers a distributed pool of expertise and infrastructure for computational life science research, servicing life science research institutions across Victoria. The LSCC currently has 20 staff.

The IBM Collaboratory provides high-level supercomputing support in accordance with the funding agreement between Government, the University of Melbourne and IBM. IBM researchers work side-by-side with researchers from the University of Melbourne, medical research institutes in the Parkville Precinct, and other universities in Melbourne. There are currently four IBM Collaboratory staff who are co-located at the VLSCI and contribute to its research support and skills development efforts.

The formal relationships between VLSCI's governance committees, Directorate, the PCF, the LSCC, the outreach Program and the IBM Collaboratory are illustrated in Figure 3.

FIGURE 3 **GOVERNANCE AND OPERATIONAL MODEL**



SOURCE: VLSCI 2013, 'VLSCI Governance', http://www.vlsci.org.au/page/our-people

2.4 VLSCI facilities

2.4.1 The Peak Computing Facility (PCF)

The PCF is a world class petascale facility with four systems built on two architectures (BlueGene/Q and x86) which are dedicated to life sciences research. Each system offers varying memory and data-handling capacities to suit the large memory computational resources required from genomics to high capacity processing of computational imaging data.

A summary of the current computing hardware is provided in Table 4.

TABLE 4 **PCF HARDWARE**

Hardware	Specifications
IBM Blue Gene/Q - Avoca	— Peak performance of 838.86 teraFLOPS. — 65,536 PowerPC based 1.6GHz cores. — A total of 64TB RAM. — Interconnect between compute nodes forms a five-dimensional torus providing excellent nearest neighbour and bisection bandwidth. — Suitable for large-scale parallel processing. — Connected to a 1,100TB GPFS storage system (shared with Barcoo and Merri). — Compute nodes run a custom lightweight operating system called Compute Node Kernel (CNK) that is similar to Linux and mostly POSIX compliant. — The head node runs the RHEL 6 operating system, a variety of Linux.
SGI Altix XE Cluster - Bruce	— Peak performance of 11.6 teraFLOPS. — 1088 Intel Nehalem compute cores (8 per node) running at 2.66GHz. — 110 nodes with 24GB RAM per node. — 20 nodes with 48GB RAM per node. — 6 nodes with 144GB RAM per node. — Connected to a high speed, low latency QDR Voltair Fabric InfiniBand network for inter-process communications. — Connected to a 100TB Panasas file system. — The system runs the RHEL 6 operating system, a variety of Linux.
IBM iDataplex x86 system – Merri	— Peak performance of 7.3 teraFLOPS. — 688 Intel Nehalem compute cores running at 2.66GHz. — 36 nodes with 96GB RAM and 8 cores per node. — 44 nodes with 48GB RAM and 8 cores per node. — 3 nodes with 1024GB RAM and 16 cores per node. — Connected to a high speed, low latency QDR Voltair InfiniBand switch for inter-process communications. — Connected to a 1,100TB GPFS storage system (shared with Avoca and Barcoo). — The system runs the RHEL 6 operating system, a variety of Linux.
IBM iDataplex x86 system - Barcoo	— Peak performance - compute nodes currently performing at 20 teraFLOPS (ie. excluding Xeon Phi cards) — 1120 Intel Sandybridge computer cores running at 2.7GHz. — 67 nodes with 256GB RAM and 16 cores per node. — 3 nodes with 512GB RAM and 16 cores per node. — 20 Xeon Phi 5110P cards installed across 10 nodes. — Connected to a high speed, low latency Mellanox FDR14 InfiniBand switch for inter-process communications. — Connected to a 1,100TB GPFS storage system (shared with Avoca and Merri). — The system runs the RHEL 6 operating system, a variety of Linux.

SOURCE: Personal communication and VLSCI 2013, 'System Architecture', http://www.vlsci.org.au/gettingstarted/system-architecture

The hardware has a storage capacity of:

— 100TB Panasas Parallel Data Store (attached to Bruce)

— 470TB GPFS Parallel Data Store (shared by Avoca, Barcoo and Merri).

The PCF makes available over 250 open source and commercial software programs on its systems at no cost to users or institutes (unless there are users who are required to pay commercial rates). Users and potential users with particular software needs can make requests (via a Help Tracking System) for access to specific purpose software. A long list of the available software for use at PCF is available from the VLSCI website.[12]

2.4.2 The Life Sciences Computation Centre (LSCC)

The LSCC is a research centre providing strategic support services to enable Victorian life science researchers to transform their research through access to the

[12] http://www.vlsci.org.au/documentation/software-applications

VLSCI's supercomputing facility. The LSCC employs experts within the themes of Genomics, Bioinformatics and Integrative Biology, Computational Bio-Imaging and Molecular Dynamics to build the necessary cross-disciplinary research collaborations and scale-up projects to efficiently use the processing power being delivered.

The LSCC provides a range of support and capacity development services to life science researchers and research groups operating across Melbourne. These services include subscription services (made up of distinct services) and a capacity development program.

A summary of these services and the program is provided in Table 5.

TABLE 5 **LSCC'S SUBSCRIPTION SERVICES**

Service	Description
Embedded services	An institution reimburses the LSCC for a portion of the cost of a staff scientist (normally 0.5 or 1.0FTE) employed to attend the institution and offer broad project and capacity building support into its research teams.
Community development service	Expressions of interest in research collaboration may be lodged with the LSCC. The LSCC Advisory Committee reviews them regularly and recommendations on resource allocation are made to the VLSCI Director for approval. Over 2013/14 access to LSCC collaborative project support will continue to be subsidised by the VLSCI, and while the LSCC aims to provide some level of support to all project requests, where significant support is requested preference will be given to projects which consider a financial contribution or subscription to the LSCC.
Grant support service	Access the reputation of the LSCC team and its high-impact results to work together towards a grant-funded collaborative subscription, with LSCC assisting in the grant application process, including the budget items for its services e.g. full or partial salaries for bioinformatics as budget items. If successful, the LSCC will then provide collaborative support directly to the project through salary reimbursement. At all levels of engagement collaborators are able to take advantage of the full expertise and resource base of the LSCC, including the extensive high performance computing (HPC) and support resources provided through the VLSCI, best practice tools and workflows, education and training resources, community knowledge and outreach benefits.

SOURCE: VLSCI 2013 'LIFE SCIENCE COMPUTATION SUPPORT CENTRE', http://www.vlsci.org.au/page/research-support-services

In addition, the LSCC manages an active Community Development Program for students and researchers from collaborating institutions. The Community Development Program invites researchers to join the LSCC one day a week for between three and twelve months as an in-kind contribution to the LSCC from collaborating institutions.

Participants contribute to the pool of expertise and resources and transfer knowledge and experience back to their host institutions and other research initiatives. Knowledge sharing and dissemination about new approaches and tools for common activities is a particular focus of the Community Development Program.[13]

2.5 Alternatives to VLSCI

VLSCI is one of the best life science supercomputers in the world. According to the June 2013 *Top500* list, VLSCI's Avoca is the fastest life sciences supercomputer in the world. VLSCI is ranked 39th when compared against all supercomputers.[14]

2.5.1 International alternatives

Three other life sciences computers (two located in the United States and one Japan) were included in the *Top500* list (see Table 6), with a further two (located in

[13] VLSCI 2013 'Life Science Computation Support Centre', http://www.vlsci.org.au/Page/Research-Support-Services

[14] *Top500* is a biannual ranking of supercomputers that is compiled by a group of academics in Germany and the United States. Top500 ranks according to the number of FLOPs processed per second.

Poland and Japan) identified but not making the list in June 2013. Compared to these international life sciences supercomputers, the performance of VLSCI is far superior, running nearly 600 teraFLOPS faster than its closest competitor.

TABLE 6 **LIFE SCIENCES SUPERCOMPUTERS IN THE *TOP500*, JUNE 2013**

Top500 Rank June 2013	*Top500* Rank November 2012	*Green500* Rank June 2013	Installation site	Manufacturer – Computer name	Number of cores	Tflop/s (max)
39	**33**	**22**	**VLSCI**	**IBM – "Avoca"**	**65,536**	**715.6**
331	208	Not ranked	University of Chicago/ Computation Institute	Cray – "Beagle"	17,856	125.8
468	301	331	University of Tokyo/ Human Genome Centre	Hitachi – "Shirokane2"	16,128	100.6
492	313	489	Pacific Northwest National Laboratory (Environmental Molecular Sciences Laboratory)	HP – "Chinook"	18,176	97.1
Not ranked	375	Not ranked	Polish Academy of Science/ Institute of Bioorganic Chemistry	SGI	9,498	89.8
Not ranked	432	Not ranked	Japanese National Institute of Genetics	HP	5,616	82.9

SOURCE: http://www.genomeweb.com/informatics/australias-avoca-retains-spot-fastest-life-science-supercomputer; *HTTP://WWW.TOP500.ORG/LISTS/2012/11/; http://performrecruitment.com.au/australia-scores-best-ever-supercomputer-ranking/*

An alternative ranking of supercomputers takes into consideration the environmental credentials of the machine. The *Green500* index provides a ranking of the most energy efficient computers in the world. According to the *Green500* website:

> For decades, the notion of "performance" has been synonymous with "speed" (as measured in FLOPS, short for floating-point operations per second). This particular focus has led to the emergence of supercomputers that consume egregious amounts of electrical power and produce so much heat that extravagant cooling facilities must be constructed to ensure proper operation. In addition, the emphasis on speed as the ultimate metric has caused other metrics such as reliability, availability, and usability to be largely ignored. As a result, there has been an extraordinary increase in the total cost of ownership of a supercomputer.[15]

VLSCI features equally prominently on the most recent *Green500* for June 2013, with Avoca coming in in 22nd place. The closest international life sciences rival "Shirokane2" came in in 331st place and "Chinook" in 489th place (see Table 6).

With the advent of more and more data-intensive supercomputer applications, some HPC platforms designed more for 3D physics simulations are unsuitable. Existing benchmarks and performance metrics do not assess suitability for these data-intensive applications. A new set of benchmarks – the Graph 500 – involving graph algorithms, a core part of many analytics workloads, is now being put in place.

This is the first serious approach to complement the Top 500 with a performance rating more appropriate to data-intensive applications. The Graph 500 was announced at the International Supercomputing Conference in 2010 and the first list appeared in *Supercomputing* in 2010. The latest listing, published in June 2013, ranks Avoca equal 7th. The full list can be accessed at: www.graph500.org.

2.5.2 Alternatives in Australia

There are seven supercomputers in Australia that have also been recently ranked in the June 2013 *Top500* (see Table 7), with VLSCI's 'Avoca' the second best

[15] http://www.green500.org/

performing supercomputer in the country behind the new NCI facility commissioned at the Australian National University at the end of July 2013.

TABLE 7 **SUPERCOMPUTERS IN AUSTRALIA INCLUDED IN *TOP500***

Rank June 2013	Rank November 2012	*Green500* Rank June 2013	Installation site	Manufacturer – Computer name	Number of cores (June 2013)	Tflop/s (max)[c] (June 2013)
27	24	141	NCI, ANU	Fujitsu – 'Raijin'	53,504	978.6
39	**33**	**22**	**VLSCI**	**IBM – 'Avoca'**	**65,536**	**715.6**
289	183	44	CSIRO	Xenon – 'CSIRO GPU Cluster'	7,308	133.7
320	207	193	NCI-NF [b]	Oracle - 'Vayu'	11,936	126.4
460	297	191	Department of Defence	IBM	10,776	102.0
Not ranked	395	Not ranked	iVEC	HP	9,600 [a]	87.2 [a]
Not ranked	462	Not ranked	Digital Content Provider	HP	7,168 [a]	78.8 [a]

[a] November 2012. [b] "Vayu" is scheduled to go out of service on 30 September 2013 with projects moving to the "Raijin" system launched on 31 July 2013. [c] This refers to the maximum (observed) sustained performance rather than peak performance.

SOURCE: http://www.top500.org/lists/2012/11/; http://www.top500.org/lists/2013/06/

Before the launch of the new Canberra NCI supercomputer ('Raijin') in July 2013, The VLSCI was the fastest machine in the southern hemisphere. One of the major uses of the NCI supercomputer is for climate modelling.

Several stakeholders commented that the 'support package' available to users of the VLSCI was the only one of its kind in Australia and that they were not aware of any similar life sciences dedicated facility operating overseas. One noted that:

> (VLSCI) provides unique expertise to fill critical research gaps.

3 Benefits currently being realised

Below we discuss some of the benefits that are currently being delivered as a result of life science researchers having access to the VLSCI supercomputing facilities.

3.1 Research outputs

The results of scientific research are normally presented at conferences and or published in peer reviewed academic journals.

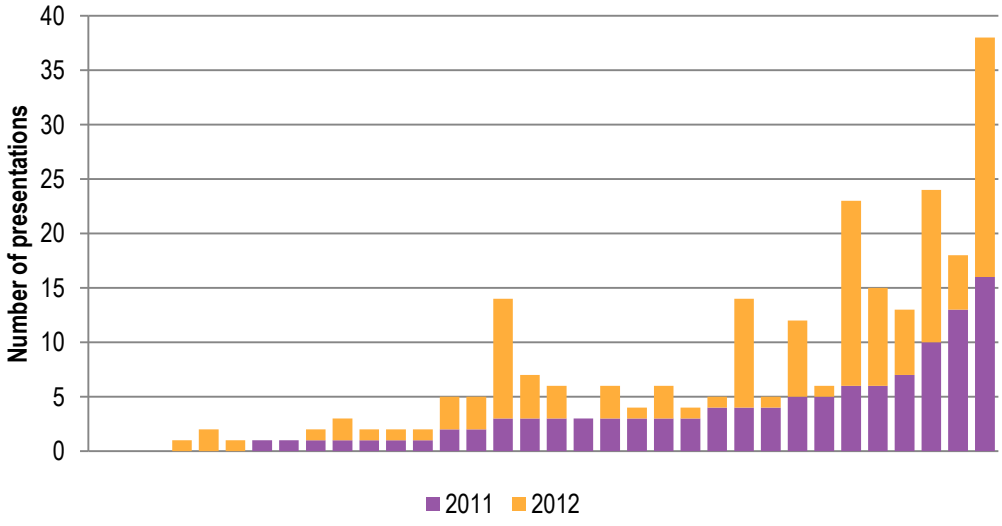
In 2011, the 42 respondents to a VLSCI questionnaire reported that they collectively had given 121 presentations and published 76 journal articles as a result of their VLSCI project. In 2012, 51 questionnaire respondents reported that they had collectively given 177 presentations and published 119 journal articles as a result of their VLSCI supported research.

It is important to note that there were an extra nine respondents in 2012 compared with 2011 and this partially explains the increase in the number of presentations and publications. However, even if we consider only the presentations and publications of those respondents that reported in both 2011 and 2012, there is still evidence that the number of presentations and publications resulting from VLSCI projects increased from one year to the next.

3.1.1 Presentations

With respect to presentations in 2011 and 2012, 34 respondents reported 115 presentations in the first year and 135 presentations in the second year. The distribution of the total number of presentations for each of the 34 projects across both years is shown in Figure 4.

FIGURE 4 **PRESENTATIONS OF RESEARCH RESULTS IN 2011 AND 2012**



Note: Each column represents one project. Projects are not ordered by project number.

SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

Of the 34 respondents:

- 28 presented in both 2011 and 2012. Of this group
  - seven made the same number of presentations in 2011 and 2012
  - 14 presented more in 2012 than in 2011.

During 2012, there were 18 presentations resulting from LSCC projects, 15 of which acknowledged LSCC's role in their research. A further 23 presentations have been made so far in 2013, with 21 acknowledging the role of LSCC.

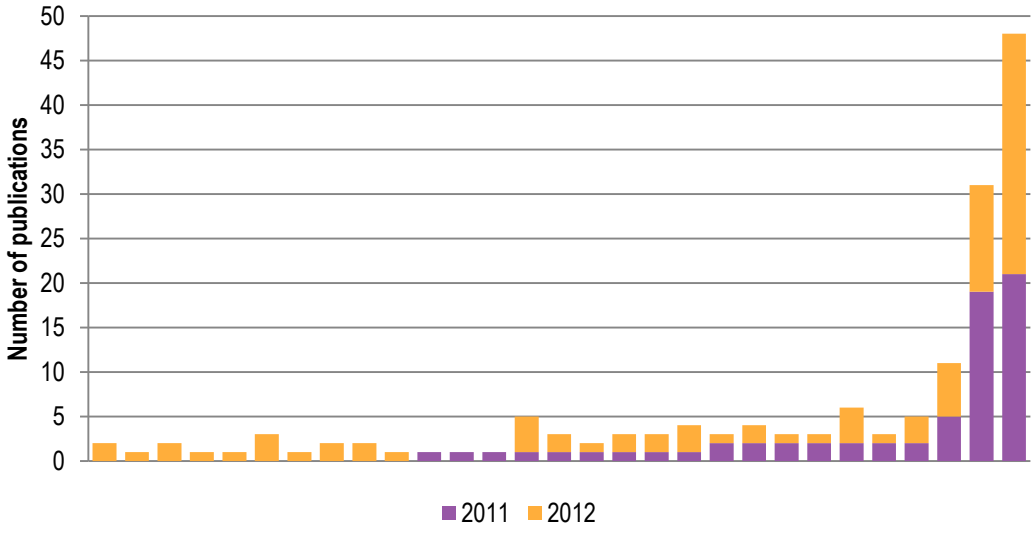
3.1.2 Publications

With respect to publications, the same 34 respondents reported 68 publications in 2011 and 88 publications in 2012 (see Figure 5). Of the 34 respondents:

- 10 published for the first time in 2012
- 16 published in both 2011 and 2012. Of this group:
  - two had the same number of publications in 2011 and 2012
  - nine had more publications in 2012 than in 2011.

While the number of publications increased over time, this is not surprising as it can take more than a year to carry out a project. However, it is certainly a more positive sign that the research being done at VLSCI is well regarded than if the number of publications had declined over time.

FIGURE 5 **PUBLICATIONS IN 2011 AND 2012**



Note: Each column represents one project. Projects are not ordered by project number. Projects in Figure 4 and Figure 5 do not align.
SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

In 2012, eight papers linked to LSCC projects were published, of which five acknowledged LSCC affiliation. To date in 2013, a further eight papers have been prepared, five of which have already been published.

3.1.3 Journal Impact Factor

As noted above, the number of publications by itself is not a sufficient measure of VLSCI's success in facilitating research in the life sciences field. The quality of the

research done is a more important indicator. The relative quality of a particular research project is something that often only emerges over time.[16]

However, a useful indicator of research quality can be obtained by considering the standing of the journal that the work is published in. Journal Impact Factors (JIFs) are often used to compare one journal's relative standing against others in the same field.

Since 1975, Thomson Reuters has published the *Journal Citation Report* which has provided quantitative tools for ranking, evaluating categorising and comparing journals. The JIF is one of these tools; it is a ratio between the number of citations and recent citable items published. It is determined as follows:

> **A** = total cites in Year X
>
> **B** = Year X cites to articles published in Year X-1 (this is a subset of A)
>
> **C** = number of articles published in Year X-1
>
> **D** = B/C = Year X impact factor.[17]

According to Thomson Reuters:

> [T]he impact factor can be used to provide a gross approximation of the prestige of journals in which individuals have been published. This is best done in conjunction with other considerations such as peer review, productivity, and subject specialty citation rates… The impact factor should not be used without careful attention to the many phenomena that influence citation rates, as for example the average number of references cited in the average article. The impact factor should be used with informed peer review.

The JIF attempts to remove some of the bias linked to large journals, more frequently issued journals and newer journals. It is not straight forward to define what a 'good' impact factor is. For example, a JIF of 0.99 for a journal in one discipline can indicate a leading journal in that discipline, while a JIF of 11.5 in another discipline can indicate a 'lower ranked' journal in that discipline. For this reason, JIFs do not provide an 'absolute' ranking of a journal. Generally speaking most JIFs are below five and very few are above 20 (the highly respected journal *Nature* has an impact factor of 38.597).

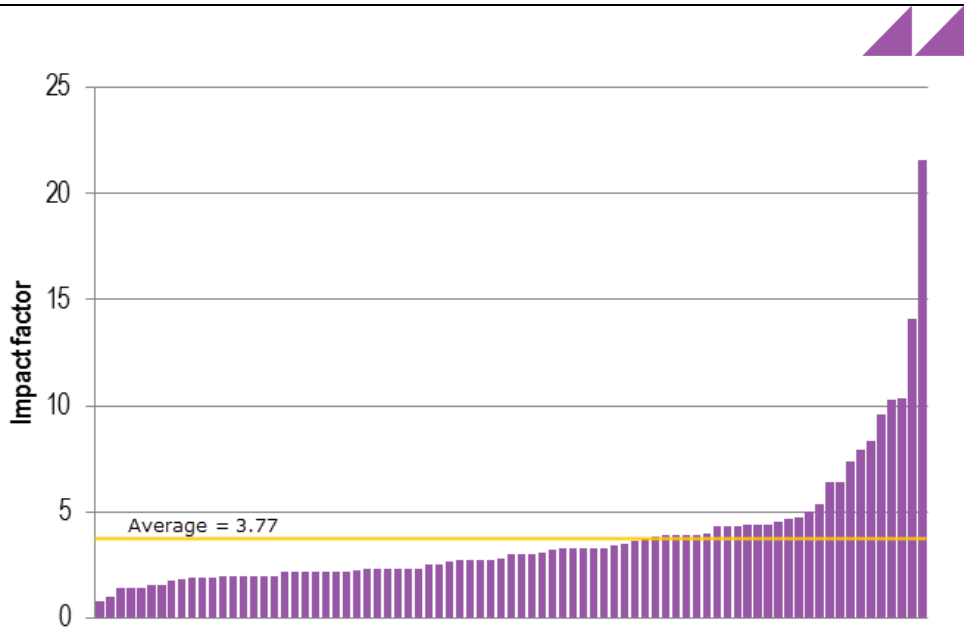
It is also important to understand that JIFs are not a measure of the impact of individual articles. For this study we are using JIFs to gain an overall assessment of the quality of the body of research facilitated by VLSCI.

The JIF of the journals in which articles generated by VLSCI projects ranged between 0.818 and 21.543, with an average impact factor of 3.77 (see Figure 6).

[16] An illustration of this is provided by considering the Nobel Prize winners. Often the prizes are awarded decades after the research was originally published. For example, the 2013 Nobel Prize for chemistry was awarded for pioneering work on computer programs that simulate complex chemical processes. Those programs were first developed in the 1970s.

[17] *The Thomson Reuters Impact Factor*, Retrieved September 3, 2013, from Web of Knowledge: http://wokinfo.com/essays/impact-factor/

FIGURE 6 **DISTRIBUTION OF IMPACT FACTORS FOR REPORTING PROJECTS IN 2012**



Note: 1. Distribution of 81 publications only. 2. The average impact factor is for all publications which means that the same journal may be counted more than once in the average.

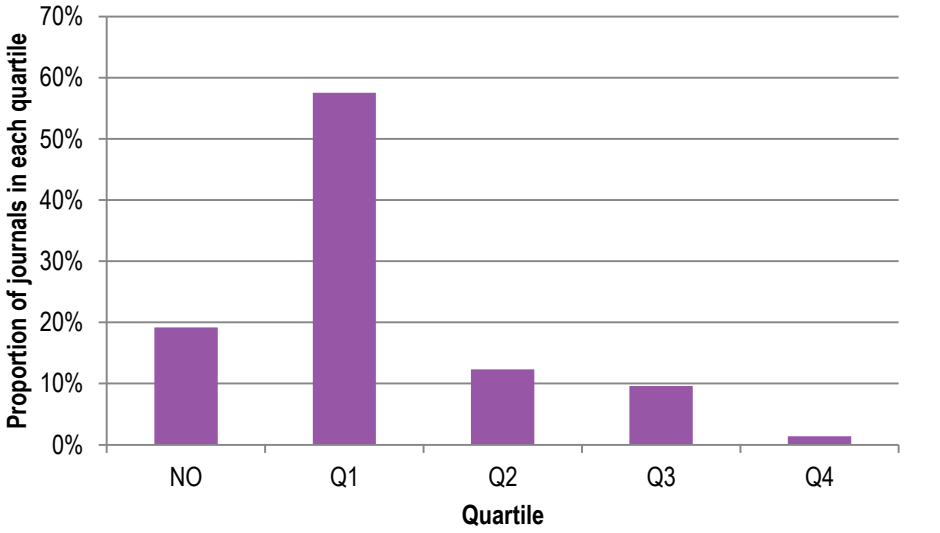
SOURCE: 2012 ANNUAL REPORT SUMMARIES, RELEVANT JOURNAL WEBSITES.

The JIFs for LSCC publications also rate well. Seven of the 2012 papers have been published in journals with JIFs ranging between 1.68 and 10.603, with an average JIF of 5.288.

Thomson Reuters ranks journals (based on their JIFs) in quartiles based on journal disciplines; a journal in the first quartile (Q1) is ranked in the top 25 per cent of its category. Analysis of the publications by VLSCI projects reveals that 57 per cent of the journals used were in the first quartile, i.e. in the top 25 per cent of journals in their category (see Figure 7).

The high proportion of publications in journals ranked in the first quartile provides a strong indication that the research projects giving rise to those publications are likely to be highly regarded globally.

FIGURE 7 **QUARTILE ALLOCATION OF JOURNALS PUBLSIHING VLSCI MATERIAL IN 2012**



Notes: 1. "NO" indicates that the journal is not included in the *Journal Citation Report.* 2. Some journals publishing VLSCI material were in more than one subject category. In such cases the highest impact factor has been used.

SOURCE: THOMSON REUTERS AND ACIL ALLEN CONSULTING.

3.2 Leveraged research co-funding

In 2011, 15 (out of 42) respondents to VLSCI's questionnaire reported that their ability to access the VLSCI facilities contributed to at least $12.04 million in grants coming to their Victorian institution. This included 18 Australian grants and four international grants. Of the Australian grants, eight were from the National Health and Medical Research Council (NHMRC), and five were sourced from the Australian Research Council (ARC) under the Discovery and Linkage programs.

In 2012, 19 (out of 51) respondents reported that access to VLSCI contributed to at least $13.39 million in 'new' grants coming to their Victorian institution (i.e. grants over and above those reported in 2011). This included 32 Australian grants and two international grants. Of the Australian grants, 15 were sourced from the NHMRC and 12 were sourced from the ARC. The remaining Australian grants were from Cancer Australia, nVidia and the Victorian Department of Health.

The total number and value of the grants in 2011 and 2012 are compared in Table 8.

TABLE 8 **GRANTS AWARDED TO VLSCI PROJECTS IN 2011 AND 2012**

Total grants					*Type of grants*			
Year	Projects reporting grants	Australian Grants	International grants	Value of grants	*ARC Discovery*	*ARC Linkage*	*NHMRC*	*Other*
2011	15	18	4	$12,043,205	*1*	*4*	*8*	*9*
2012	19	32	2	$13,393,144	*11*	*2*	*15*	*6*

SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

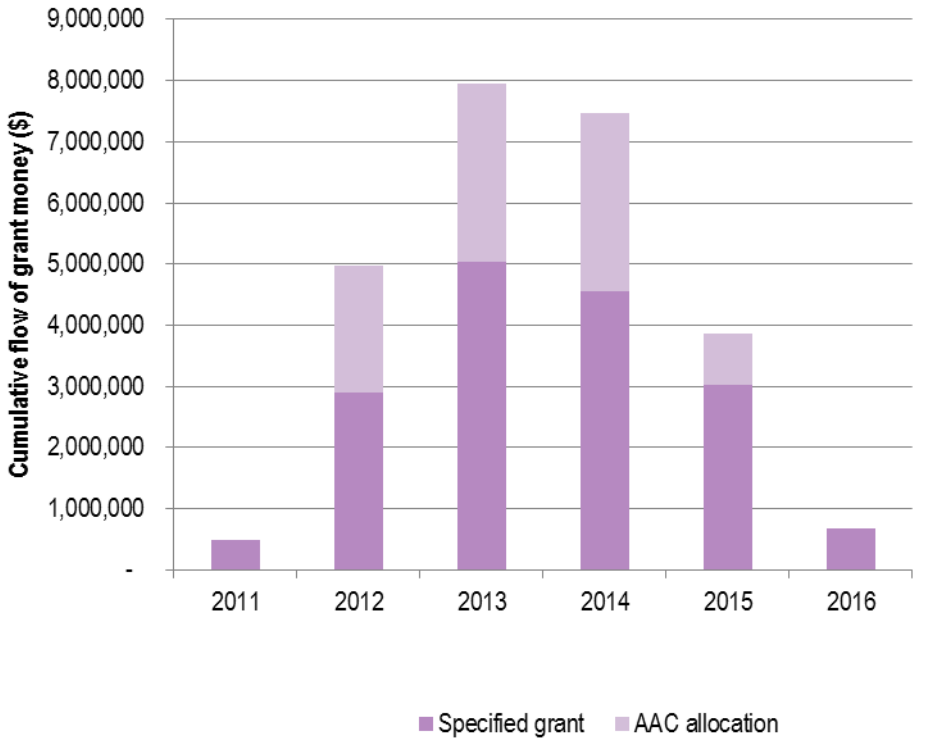
The annual flow of grant monies linked to VLSCI is shown in Figure 8. In addition to identifying the value of the grant, 33 respondents identified the duration of the grant. The flow of these funds is shown in the darker segment ("Specified grant"). A further 12 respondents identified the grant value but not the duration. ACIL Allen allocated assumed that these grants all were over three years and that the first year of the

grant was in the year after the grant was awarded. The resultant flow of funds is identified by the lighter segment shown in Figure 8 (the "AAC allocation").

Combining the two flows provides an estimate of the annual flows of research funds into Victoria each year as a result of VLSCI. In 2011, approximately $492,145 in research funds flowed into Victoria. This increased to almost $4.97 million in 2012 and around $7.47 million in 2013. The cumulative flow of funds into Victoria over the period 2011 - 2016 is around $25.4 million based on the grants shown in Figure 8. Importantly, this is an 'at least' value; 12 respondents reported that they received grants as a result of VLSCI however the amounts they were granted was not specified.

The projected decline in grants flows from 2014 onwards should not be interpreted as a negative signal. The analysis assumes that no new research grants are awarded to VLSCI projects, a highly unlikely outcome.

FIGURE 8 **ANNUAL FLOW OF VLSCI GRANT MONIES, 2011-2016**



SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

A number of LSCC projects also received grants which further increases the total of research funds flowing into Victoria. Fifteen grants were applied for in 2011 and 2012, with eight of these applications successful (three in 2011 and five in 2012). These grants, worth a total of $4.2 million, were received from Monash University, the Monash-Siemens Collaboration, NeCTAR, Cancer Australia, NHMRC and the Victorian Comprehensive Cancer Centre. LSCC projects have applied for 25 grants in 2013 (for research commencing in 2014). The outcomes of these applications are not known at this time.

Researchers indicated that their ability to access VLSCI facilities was essential to their ability to gain access to grants. For example, comments provided by researchers included:

> We believe that the VLSCI contributed to our grant success in obtaining a grant from the NHMRC to conduct epilepsy research. In all of our Biomedical Engineering grant applications that require substantial computing resources, we directly mention the VLSCI as a resource that we can count upon to use for our research…
>
> We received 7 new NHMRC project grants commencing 2013 which rely on HPC, and use of VLSCI was included in the research proposals. Our impression is this contributes to the perceived feasibility of the proposals…
>
> …the VLSCI has been completely "pivotal" in being able to win research funding. Access to the PCF was a key factor in winning grant funding from the U.S. AFOSR …This grant is very high profile - it is a consortium-based grant with 5 Chief Investigators……Given the AFOSR fund very few research groups in Australia, the securing of this support, and maintaining this support in the future, is very important for leveraging future AFOSR funding…

During an interview with one stakeholder they noted that the VLSCI's location in the Parkville Precinct is helping projects capture a lot of ARC and NHMRC funding.

The increase in the number and value of the grants awarded between 2011 and 2012 suggests that the results obtained by researchers using VLSCI are regarded by the peer reviewers of grants agencies as showing some promise.

The grants awarded by the ARC provide some insights into the nature of the VLSCI projects. Discovery grants support fundamental research whereas Linkage grants support research designed to use scientific knowledge to solve existing problems (often in partnership with the private sector). Specifically, according to the ARC:

- **Discovery** supports fundamental research, essential to Australia's innovation system, for the development of new ideas, job creation, economic growth, and an enhanced quality of life in Australia…
- **Linkage** promotes national, and international, collaboration and research partnerships between key stakeholders, in research and innovation, including higher education providers, government, business, industry and end users. Research and development is undertaken to apply advanced knowledge to problems, acquire new knowledge and as a basis for securing commercial and other benefits of research.[18]

As shown in Table 8, only one Discovery grant was awarded to a VLSCI researcher in 2011 however 11 new Discovery grants were awarded in 2012. The awarding of Discovery grants indicates that research project peer reviewers view the fundamental research being undertaken at the VLSCI facilities as high quality and important.

VLSCI is also contributing to the application of research to addressing society's life science related problems as illustrated by the total of six Linkage grants were awarded to researchers using VLSCI facilities in 2011 and 2012.

The cumulative flow of funds into Victoria over the period 2011 - 2016 is thus around $29.6 million based on all the grants discussed above.

3.3 Additional research employment generated

In 2011, 24 (out of 42) respondents reported that VLSCI had contributed to creating additional employment opportunities (directly or indirectly) within their research group and/or collaborators. Nineteen of these respondents reported a total increase of 36 individuals, with the remaining five respondents not indicating the exact number of employment opportunities created. However, if we assume that the latter

[18] *National Competitive Grants Program*, Retrieved August 30, 2013, from http://www.arc.gov.au/media/fact_sheets/ARC_NCGP.pdf

all employed at least one additional person then this would mean that VLSCI contributed to creating at least 41 new jobs in 2011.

In 2012, 24 (out of 51) respondents reported that VLSCI had contributed to creating additional employment opportunities (directly or indirectly) within their research group and/or collaborators. Sixteen of these respondents reported a total increase of 30 persons employed. The remaining eight respondents did not specify the number of additional persons employed. Again, if we assume that the latter all employed at least one additional person then this would mean that VLSCI contributed to creating at least 38 new jobs in 2012

The additional persons employed were in the main highly qualified (graduates or above). The level of academic qualifications of the additional employees in each year is shown in Table 9. Where the level of qualifications was specified the new employees were almost all post graduates or above.

TABLE 9 **ADDITIONAL EMPLOYMENT CREATED BY VLSCI IN 2011 AND 2012**

Year	Doctorate and above	PhD	Post doctorate	Post graduate	Graduate	Undergraduate	Intern	Researcher	Unknown	Total
2011	3	5	5	3	0	1	0	1	18	36
2012	1	6	9	2	2	0	1	1	8	30

Notes: 1. Only the responses that specified the number of new employees are included in the data above. 2. The extent to which 'new' employment in 2012 is additional to that in 2011 is unclear.
SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

Unfortunately, the design of the questionnaire used to collect the data on employment means that it is not possible to state with certainty whether the additional employment in 2012 is over and above the additional employment generated by VLSCI in 2011. The available data also does not allow us to say with certainty whether any of the persons gaining employment as a result of research projects associated with VLSCI would have found employment in other research projects in the absence of VLSCI.

Nonetheless, it is possible to say that some 36 additional jobs have been generated as a direct or indirect result of VLSCI. It is possible that the cumulative number of new employment opportunities could be as many as 79 (and possibly more).

One stakeholder said that in their particular area of research (bio imaging) four specialists in the field had been employed to assist researchers using the VLSCI, two from Australia and two from overseas.

3.4 Capacity development

3.4.1 Staff and student training

Stakeholders who spoke of VLSCI's work to support education and training were uniformly complimentary of that effort. One stakeholder noted that several of her research group's students had obtained VLSCI support for travel to attend a workshop. One of those had also gone on to get a grant to top up their PhD scholarship.

The opportunities for training provided by the VLSCI are in themselves attracting people to Victoria. One stakeholder noted that:

> VLSCI has enabled me to attract top quality research students, who have also benefitted from internships with IBM.

Another stakeholder commented that the 'capacity and capacity building' offered by VLSCI through scholarships and financial support to students was fundamental to

Melbourne becoming a leading biological sciences hub, and that these grants were the first step in building long term capability in life sciences.

Section 5.4 discusses the VLSCI's outreach activities in more detail.

LSCC also plays an important training role. It runs regular seminars and workshops that provide training to students and staff. Each of these is discussed briefly below and also in section 5.3.

One stakeholder noted that one of the reasons most bio imaging specialists from overseas were employed for two years was to ensure that there was sufficient time to train local researchers in the necessary skills.

LSCC Seminars

In 2012, there were 22 seminars attended by LSCC project stakeholders. On 21 occasions the LSCC stakeholder was an invited speaker and on 16 occasions LSCC affiliation was acknowledged. To date in 2013, 14 seminars have been attended by LSCC project stakeholders, on all occasions as an invited speaker. LSCC affiliation was acknowledged on 12 occasions.

LSCC Workshops

In 2012, 13 LSCC projects were linked to workshops, with known attendance for seven of these workshops of 240 people. LSCC affiliation was acknowledged at 12 of these workshops. LSCC projects have already been linked to eight workshops in 2013 (to date), with actual (and expected) attendance of at least 85 people and LSCC affiliation acknowledged (or expected to be acknowledged) at all.

The VLSCI's outreach activities are further discussed in section 5.4.

3.5 Collaborations

The VLSCI is highly effective in creating and supporting collaborations. The origin of the facility is built on an important collaboration between the University of Melbourne and the IBM Collaboratory for Life Sciences (the IBM Collaboratory). Staff at the IBM Collaboratory who work with VLSCI have a range of skills, including computer science, physics, mathematics, information technology and engineering. They play an active role as active participants in research projects and providing support for projects.

The LSCC is also a highly collaborative structure. It links life sciences researchers at the University of Melbourne, La Trobe University and Monash University. The activities of the LSCC highly collaborative in nature in themselves, such as fortnightly meeting of members to discuss research developments and address any challenges that have arisen. In addition, through their outreach activities they also encourage collaboration between the LSCC and other research groups.

See also discussion in sections 2.4.2 and 5.3.

4 Potential future benefits

In previous sections of this report we discussed some of the benefits that access to the VLSCI has already brought to Victoria and Victorian researchers. This section discusses some of the potential future benefits flowing from the operation of the VLSCI.

One of those is the enhanced reputation of Victoria as a global hub for life sciences research; others are the commercialisation opportunities that may flow from the research, and the prospect for improved health outcomes for people in general (and Victorians in particular) due to better detection and treatment of illnesses.

As with any discussion about the commercialisation of research outcomes there remains considerable uncertainty about the timing and scale of possible future benefits. However, there is a strong likelihood that even if only one of the commercialisation opportunities arising from VLSCI supported research projects that we have identified ultimately comes to fruition, the potential benefits could be prove to be considerable.

4.1 Enhanced reputation of Victoria as a global life sciences research hub

The Academic Ranking of World Universities (ARWU) is prepared annually by the Centre for World-Class Universities at Shanghai Jiao Tong University. The ARWU rankings of the world's top 500 universities were first issued in 2003. The overall ranking of the University of Melbourne between then and 2013 is shown in Figure 9. The trend over that time has been one of steady improvement (note that a lower number in the figure means a higher ranking).

That steady improvement in the overall ranking appears to be driven at least in part by strong improvements in the rankings for '*life and agricultural sciences*' and '*clinical medicine and pharmacy*'.[19] It is difficult to say what proportion of this improvement is due to VLSCI. However, it interesting to note that the University of Melbourne's ranking in '*computer science*' was in the range 101-150 in 2012 and 2013. Prior to then the university was unranked in that discipline.

Stakeholders who expressed a view in this area were universally very complimentary of the role VLSCI was playing in improving Victoria's reputation as a leader in the life sciences field.

One stakeholder commented that the 'capacity and capacity building' offered by VLSCI through scholarships and financial support to students was fundamental to Melbourne becoming a leading biological sciences hub, and that these grants were the first step in building long term capability in life sciences.

The same stakeholder believed that the presence of the VLSCI could also help break down 'research silos' within the Victorian life sciences community by facilitating cross-discipline research and allowing researchers from different domains to work on common problems.

[19] The data for the rankings of the 'life and agricultural sciences' and 'clinical medicine and pharmacy' disciplines are given as a range. We have used the midpoint of the range to map the change in ranking over the time shown.

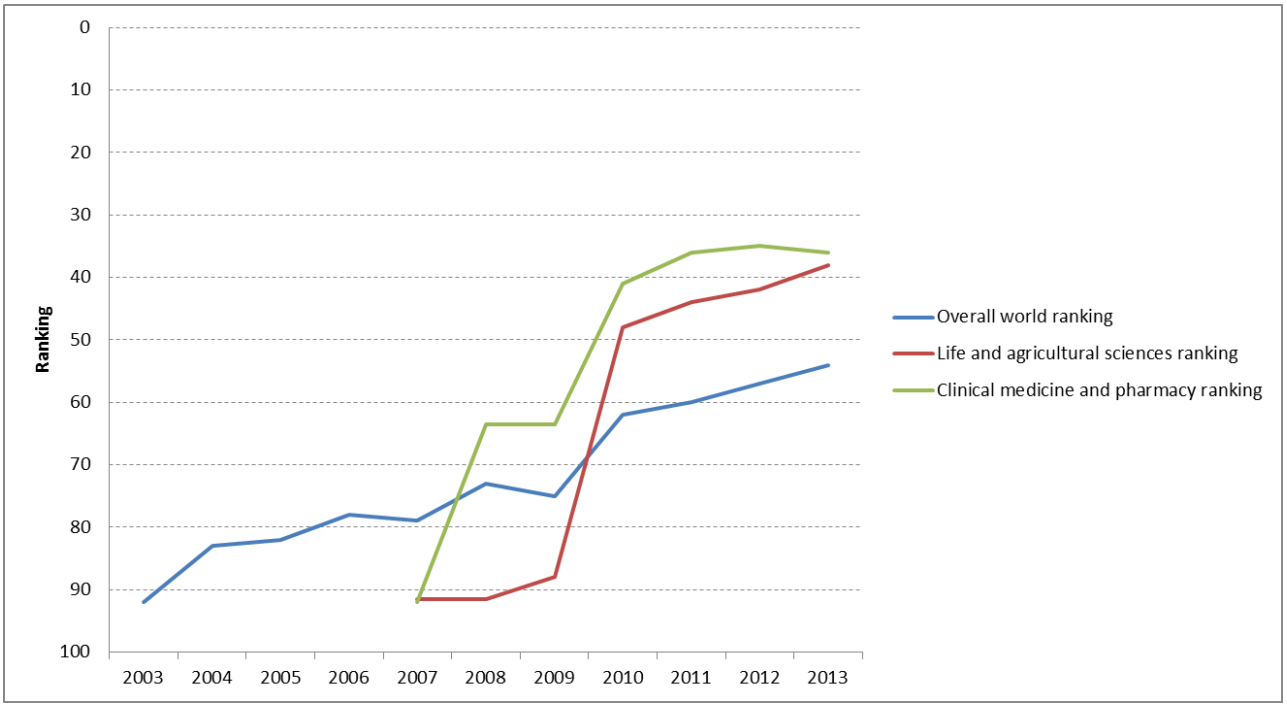
Another stakeholder commented on the support that VLSCI provides to the Victorian biosciences community helps to market Victoria as a centre for biology.

The speed with which discoveries are being made and published as a result of the computational power available through VLSCI was identified by another stakeholder as providing a major competitive advantage and helping to put Victoria on the map as a centre for life sciences expertise.

A further stakeholder noted that Victoria accounts for 30 per cent of the nation's biotechnology sector and the third largest concentration of medical expertise in the world. Another commented that access to VLSCI ensured that Victoria is at the cutting edge of life sciences research.

An analysis of the latest round of NHMRC grants awarded in October 2013 strongly supports the view that Victoria is at the forefront of life sciences research in Australia. In that round Victorian institutions received the largest share of the grants of all jurisdictions, both in terms of number of grants awarded (42.4 per cent) and the value of grants (41.8 per cent).

FIGURE 9 **ACADEMIC RANKING OF MELBOURNE UNIVERSITY**



Note: Smaller numbers imply a higher ranking.

SOURCE: http://www.shanghairanking.com/index.html

4.2 Enhanced commercialisation opportunities

During the course of this review, ACIL Allen has identified several projects where VSLCI supported research results could potentially provide commercialisation benefits to the state of Victoria, and Australia more generally. These opportunities are typically medium-to-longer-term in nature. However, some estimates suggest they could begin to deliver tangible financial benefits to Victoria in as little as 12 months.

Four of the research projects we identified have been written up as short 'case studies'. These are provided in Appendix C.

These projects often involve international collaborators from universities and major corporations working in the biological sciences. This suggests that the projects have been recognised as having the potential to deliver benefits in markets beyond Victoria or Australia as a whole, since overseas researchers and investors will be striving to deliver similar commercial outcomes to those arising in Australia.

For example, Case study 4 examines the development of a bionic eye. The research consortium supporting that project has reached a significant milestone with the support of VLSCI. In August 2013, researchers working on a prototype successfully transplanted a bionic eye into a patient with profound vision loss due to retinitis pigmentosa. That transplant has allowed the patient to perceive shapes and flashes of light for the first time.

While the implant is still an early prototype, estimates by Invest Victoria suggest its potential short term value to the Victoria's economy is more than $70 million over the period 2010-2014. Invest Victoria has also estimated that the prototype of the bionic eye will generate more than 90 new jobs for the State's biotechnology industry during this period.[20]

Case study 3 considers the potential commercial value that research into viruses can bring to a research organisation, the company that commercialises the research outcomes and the government which supports the research being undertaken in the first place. Through the support of VLSCI a team lead by University of Melbourne researchers, and supported by the St Vincent's Institute of Medical Research and the IBM Collaboratory, have developed the first 3D image of the virus responsible for 40 per cent of colds.

The image is now being used by the research team to better understand the mode of operation of a new drug, developed by a Victorian company, Biota Pharmaceuticals.[21] The image is also being used to better understand other pulmonary conditions for which there are currently no effective treatments, but which cost economies and national health systems billions of dollars per year.

The development of a successful treatment of the common cold could also be very profitable for the firm that developed it. For example, research into the structure of the neuraminidase protein during the 1980s, is credited for helping to develop anti-influenza drugs that now have an estimated annual worldwide sales value of more than $3 billion.

4.2.1 Talent and business attraction to Victoria

Major research breakthroughs in Victoria, such as the successful development of a bionic eye, a cure for the common cold or HIV/AIDS, would be certain to position the State to attract talented researchers to work on cutting edge research agendas. It would also help Victoria to attract high value adding businesses seeking to commercialise (both in Australia and overseas) the world class research being undertaken with the support of the VLSCI.

For example, the development of the Cochlear implant for certain types of deafness shows the potential benefits of supporting the development of the technology needed, over many decades, for high quality medical prosthetics. In the 1970s and

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[20] *Victorian Vision for the Future Worth $70 million*, Invest Victoria 2010, 'Press Release, http://www.invest.vic.gov.au/200410Victorianvisionforthefutureworth70million

[21] *HRV Phase IIb Study Achieves Primary Endpoint*, Biota 2012, Press Release, http://www.biotapharma.com/uploaded/154/1021819_20hrvphaseiibstudyachieve.pdf

1980s Cochlear received significant public funding to undertake and commercialise research into hearing implants and by 1983 had delivered the world's first 22 channel implant.[22]

Cochlear Ltd Australia now has subsidiaries in the US, Japan, Switzerland and Australia delivering implant systems to people in 50 countries. In October 2013, Cochlear Ltd reported to the Australian Stock Exchange a market capitalisation of approximately $3.31 billion, sales revenue of $715 million and an expected profit for 2013-2014 of more than $132 million. The firm directly employs approximately 2,700 workers across 25 countries (Cochlear 2013a).[23]

Today, the Cochlear implant stands as the world's most widely used cochlear implant system, with more than 219,000 people worldwide having received cochlear implants since the 1980s (NIDCD 2010).

Cochlear Ltd also stands as a significant example of the value that can be generated from public investment in bio medical research.

Similarly, the company that sells the anti-influenza drug Relenza, GlaxoSmithKline, currently has a market capitalisation of $123.62 billion, approximately 99,500 staff worldwide, and revenue of $46.42 billion (in October 2013).[24]

GlaxoSmithKline has a significant presence in Victoria, with laboratories that test between 4,000 and 11,000 samples each year, and factories which make and distribute products worldwide.[25]

4.3 Improved health outcomes for Victorians

This review has found that access to leading edge supercomputing facilities is assisting researchers to study significant health challenges facing the population of Victoria, Australia, and the rest of the world. Some of the benefits arising from access to VLSCI are likely to be substantial, such as the potential cost savings that new treatments and procedures will deliver to health systems. However, the timing of the delivery of such benefits remains uncertain. For example, the translation from science discovery to drug or treatment delivery within a clinical environment is normally measured in decades.

Case study 1 explores the potential benefits arising from VLSCI-supported research into ovarian cancer. Working with clinicians, Professor David Bowtell and his research team at the Peter MacCallum Cancer Centre have demonstrated that one type of ovarian cancer, notoriously resistant to conventional ovarian cancer therapy, is responsive to treatment with a drug normally prescribed for renal cancer.

This research has the potential to allow the classification of cancer according to gene activity and identify where key compounds or "markers" related to specific biochemical pathways cause cancer. Once the cancer has been effectively identified it allows for the appropriate treatment response.[26]

The Peter MacCallum team is also involved in The Cancer Genome Atlas Project, which is assembling a comprehensive catalogue of all the genetic mutations in

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[22] *Cochlear's History of Innovation*, Cochlear 2013, http://www.cochlear.com/wps/wcm/connect/intl/about/company-information/history-of-innovation/cochlears-history-of-innovation

[23] *Cochlear Annual Report to Shareholders*, Cochlear 2013, http://www.asx.com.au/asxpdf/20130913/pdf/42jbn3fb8qfy9z.pdf

[24] See for example, http://finance.yahoo.com/q/co?s=GSK+Competitors

[25] See for example, http://www.gsk.com.au/about-us_our-facilities.aspx

[26] *2011 Annual Report*, VLSCI, 2011.

human cancers. This large analytical exercise involves sequencing 500 samples of the most common cancers.

Our consultations with Professor Bowtell have identified the direct impact of Peter MacCallum team's research on current medical practice. Those research findings have been integrated into the NSW Cancer Institute's protocols/guidelines for genetic testing and referrals – these protocols and guidelines can be accessed through the eviQ Cancer Treatments Online portal.[27] Early signs indicate that, in practice, these protocols are having a positive influence on the testing and referral of cancer patients across Australia. It is anticipated that these benefits will continue to grow as additional research is disseminated amongst practitioners across Australia and overseas, and further integrated into standard medical practices and processes.

Case study 2 explores the potential benefits of research into the genomic sequencing of the common round worm, which commonly infects pigs. A team from the University of Melbourne has developed a 273 million base genome sequence of the worm. The pig based parasite is a very close relative of a parasite that infects humans.

The researchers are hopeful that the sequencing of the genome will result in the development of new vaccines, drugs and diagnostic tests for parasitic infections in animals and humans. It is also hoped that the research can be used to reveal important insights into how immune systems respond to the presence of parasites that can be applied to other disease factors such as cancer and HIV/AIDS.

One stakeholder spoke about bio imaging research into neurodegenerative disorders such as Alzheimer's, Parkinson's and Huntington's. They advised that the research being done on biomarkers that can provide early warning of disease onset is showing considerable promise. The ability to identify such diseases potentially several years in advance of symptoms manifesting themselves would prove extremely important. He commented that:

> …companies are showing a strong interest in this work due to its leading edge nature.

4.3.1 Potential economic value to communities and industries

While the timing of the health benefits to communities and industries (in the case of the roundworm research) is uncertain, the potential value of the benefit is much clearer. Based on modelling commissioned by the Cancer Council of NSW, ACIL Allen has estimated the potential value to the Victorian economy of improving the treatment of patients with ovarian cancer.

Our analysis for Case study 1 suggests that VLSCI's support for ovarian cancer research could lead to significant benefits to Victoria. We estimate that if the VLSCI supported research led to a relative conservative reduction (say 10 per cent) in the cost of diagnosing and treating cancer patients, then the benefits to the Victorian economy could be as much as $150 million (in 2013 dollars). The potential economic benefit from this one research project on its own is well in excess of the total funding support provided for VLSCI by the Victorian Government.

The analysis for Case study 2 suggests that it could generate substantial longer term economic benefits for the livestock industries of Victoria. For example, estimates by Meat Livestock Australia suggest that the national economic effect of internal parasites to the sheep industry have been over $38 million of lost income and over $83 million worth of increased expenses to producers.[28] While the same

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[27] https://www.eviq.org.au/

[28] *Assessing the Economic Cost of Endemic Disease on the Profitability of Australian Beef Cattle and Sheep Producers*, MLA (Meat Livestock Australia) 2006,

modelling has estimated that the economic cost of intestinal parasites to beef cattle was over $38 million of lost income to the industry.

With over 32,000 farms, 14.4 million head of sheep and lambs, 2 million head of beef cattle, 500,000 pigs in Victoria, there are clearly many farmers who could potentially benefit from the development of effective drug treatments against parasites.[29]

http://www.mla.com.au/CustomControls/PaymentGateway/ViewFile.aspx?mFDUp1AYI9VUf+h/ZH4CYhopVLs5O3WvlD8Tvjx4WwqIhJCS8/UdRwc9AKswn/HN3EYMKKAfsht7d1Tnt3BqiA==

[29] *Agricultural Commodities, 2011-12*, http://www.abs.gov.au/websitedbs/c311215.nsf/web/Agriculture+-+Summary+Map+-+Agricultural+Commodities

5 Preliminary evaluation of VLSCI

In this section we assess the performance of VLSCI against the targets set in the Grant Agreement with the Victorian Government. We also examine the effectiveness of the PCF, LSCC, and the VLSCI's Outreach function in meeting the key performance indicators specified for each in the VLSCI's Business Plan.

5.1 Performance against the Grant Agreement targets

The Grant Agreement between the University of Melbourne and the Victorian Government to establish the VLSCI sets three key targets:

- the cumulative value of the contributions to the VLSCI are to reach $100m by 30 June 2013
- the peak computing facility (PCF) is to rank in the top 5 facilities for life sciences research precincts internationally, with the target to be the top life sciences PCF by 30 June 2013.
- the effective annual full-time equivalent staff resources supported by the VLSCI to reach 30 full-time equivalents by 30 June 2013

Below we consider the performance against each of these targets in turn.

5.1.1 Contributions

Half the required $100 million contribution was provided by through the $50 million grant from the Victorian Government.[30] Other sources of contributions to the VLSCI are:

- cash contributions from the University of Melbourne, estimated to be $12.86 million to the end of 2013
- in-kind support from the University of Melbourne, reported to be $17.93 million to the end of 2013 (a further in-kind contribution of $3.59 million is expected in 2014)
- in-kind contributions from researchers participating in VLSCI programs.
  - the Parkville precinct is estimated to have contributed $7.27 million to the end of 2013 (a contribution of $2.42 million is anticipated in 2014)
  - other Victorian institutions are expected to have made in-kind contributions of $10.13 million by the end of 2013
- in-kind support from the LSCC, reported to be $250,000 in 2011 and $658,000 in 2012.
- other in-kind contributions to VLSCI activities from individuals providing their time and expertise to outreach activities, reported to be $213,000 in 2012
- interest on monies held, estimated to be $8.58 million to the end of 2013.

Based on the figures above the VLSCI will have received cash and in-kind contributions totalling almost $58 million by the end of 2013, comfortably exceeding the target specified in the Grant Agreement.

[30] VLSCI Business Plan 2010 -2013, dated January 2010, page 30.

We note that as part of the VLSCI's efforts to move their operations onto a more sustainable footing, the LSCC is moving towards a subscription model which aims to have researchers meeting approximately half the staff costs of the LSCC personnel collaborating on their project.

They have had some success with this approach and currently have 12 subscribers. Of the 47 major projects supported by LSCC in 2013, well over half (29) are supported by subscriptions. According to the VLSCI's 2012 Annual report, LSCC's total funding in 2013 was about $2.66 million. Approximately a quarter of that was estimated to be from institutional and project contributions. The funding for the subscription comes from either a specific line item in a group's application for a research grant or from general funding from within the research group. Current subscribers (and the source of their subscription funding) are shown below:

- Cancer Council Victoria (*state funding*)
- Eastern Hill Precinct through the Department of Medicine at St Vincent's Hospital (*internal* + *NHMRC*)
- Monash Health Translation Precinct (*internal cost recovery per client*)
- The University of Melbourne Centre for Translational Pathology (*NHMRC*)
- The NeCTAR Genomics Virtual Laboratory (*commonwealth funding*)
- The University of Melbourne Genetic Epidemiology lab (*NHMRC*)
- Monash University Department of Psychology (*unknown*)
- Monash University Central Clinical School (*internal* + *NHMRC*)
- The NeCTAR Endocrine Virtual Laboratory (*commonwealth funding*)
- Monash University School of Biomedical Sciences (*NHMRC*)
- La Trobe Institute of Molecular Sciences (*university* + *ARC*)
- Melbourne Dental School - Oral Health CRC (*industry* + *commonwealth CRC*)[31]

5.1.2 Ranking of the PCF

The Grant Agreement with the Victorian Government specifies that the peak computing facility (PCF) is to rank in the top 5 facilities for life sciences research precincts internationally, with the target to be the top life sciences PCF by 30 June 2013. The VLSCI has met this target. According to the June 2013 *Top500* list, VLSCI's Avoca was ranked as the 39th fastest supercomputer in the world in 2013. It was identified as the fastest supercomputer dedicated to life sciences research in the world in 2012 and this ranking was maintained in 2013 (see Table 6).[32]

5.1.3 Full-time equivalent staff

The Grant Agreement with the Victorian Government specifies that there are to be 30 full-time equivalent (FTE) staff resources supported by the VLSCI by 30 June 2013. According the VLSCI's Annual Report for 2012 there were 35 staff working for the organisation. There are an additional four staff working to support the VLSCI within the IBM Collaboratory.

The VLSCI has exceeded the specified target.

[31] VLSCI Annual Report 2012, page 29.

[32] *Top500* is a biannual ranking of supercomputers that is compiled by a group of academics in Germany and the United States. Top500 ranks according to the number of FLOPs processed per second.

5.2 PCF's performance against its KPIs

The PCF has five performance indicators. These are listed below along with the way in which their performance against the indicators was to be measured.

- **Achievements**. Performance against this indicator is measured in terms of key research achievements obtained by users of the PCF and developments in the computational systems and services available in the PCF.
- **Capability**. Performance against this indicator is measured in terms of availability and performance of the PCF systems indicated by the available system units, used system units, efficiency of operation and extent of parallel computation, the range of software and computational tools on the PCF systems, the capability of other systems that are integrated with the PCF systems and available to the VLSCI user community, the profile of the user and systems support services available to PCF users and the number of staff in the PCF.
- **Demand and Accessibility**. Performance against this indicator is measured in terms of the extent of demand for the PCF (e.g. number requesting resource grants, organisations, research discipline, requested and granted resource allocations), the extent of use of the PCF indicated by the number of organisations represented by users, projects, users and use of resource allocations and the profile of grants (number, size of grants).
- **Contributions**. Performance against this indicator is measured in terms of the size of the in-kind contributions from users of the PCF and the extent to which these contributions are new.
- **Customer service**. This is measured through the results of surveys of the level of researcher satisfaction and the number of users participating in training courses and workshops on the use of the PCF.

5.2.1 Achievements

It is difficult to objectively measure performance against the *Achievements* indicator. Research programs tend to deliver a mix of achievements through their research projects. By their very nature, the results of research are unknown until the research has been completed. Furthermore, the true impacts of research are not always fully clear until a considerable amount of time after the results are obtained.

However, the indications are that the research supported by the PCF is delivering high quality outcomes. The analysis in section 3.1 shows that the number of publications and presentations resulting from VLSCI supported research is increasing over time, even allowing for the fact that the number users is also increasing.

More importantly, the fact that a high proportion of the journals that the research results have been published in are ranked in the first quartile in terms of their impact in the relevant fields of research is an indication that the results of VLSCI supported research are likely to be well regarded globally.

The fact that a number of VLSCI's research projects have been the recipients of awards supports the view that the research is well regarded. Awards for VLSCI supported research include:

- the High Performance Computing Innovation Excellence Award at Supercomputing 2012 in Salt Lake City, USA, for the work in modelling the rhinovirus (common cold virus)
- the $25,000 L'Oréal Australia and New Zealand For Women in Science Fellowship awarded to Dr Kat Holt's research into multidrug-resistant bacterial infections.

— the 2013 Prime Minister's Prize for Science was awarded to Professor Terry Speed for his contribution to making sense of genomics and related technologies.

Professor Speed is Head of Bioinformatics at the Walter and Eliza Institute of Medical Research. Professor Speed is a member of the VLSCI Scientific Advisory Committee.

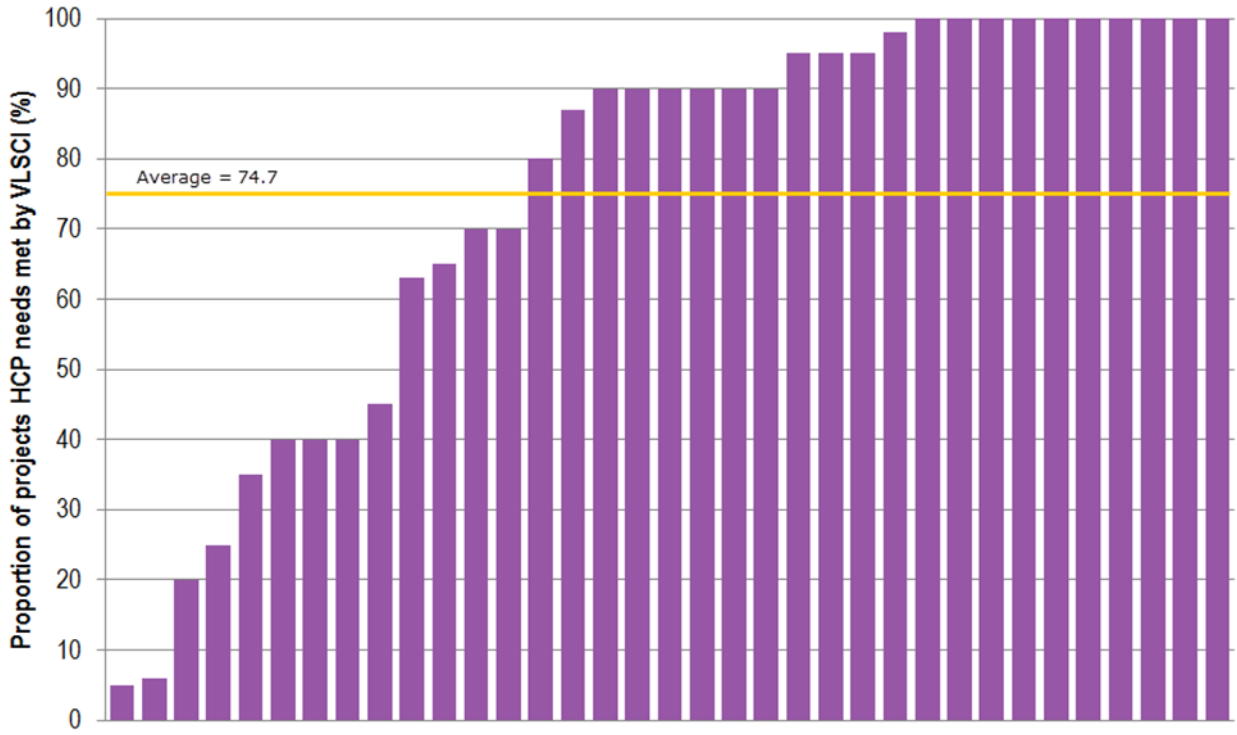
The expansion over time of the systems and services provided by the PCF appears to have occurred very smoothly. Several stakeholders referred to the 'dream run' that the VLSCI had experienced in terms of 'up time' during its first two years of operation. The facility did experience some 'down time' in early 2013. This coincided with air conditioning problems and a key IBM staff member moving away from Melbourne. Stakeholders have also noted that the situation has improved more recently and that the periods of down time have decreased.

The discussion above also provides some insights of how the PCF is performing against the '*Capability*' indicator. System availability has (despite a few recent problems) has generally been high.

5.2.2 Capability

VLSCI conducts an annual survey which asks project leaders to identify the proportion of their HPC needs that were met by VLSCI in 2012. Of the 35 respondents (out of the 51leaders surveyed) ten reported that their HPC needs were fully met by VLSCI. A further ten respondents reported that 90 to 99 per cent of their HPC needs were met by VLSCI in 2012. The average proportion of HPC needs met by VLSCI was 74.7 per cent (see Figure 10).

FIGURE 10 **PROPORTION OF HPC NEEDS MET BY VLSCI IN 2012**

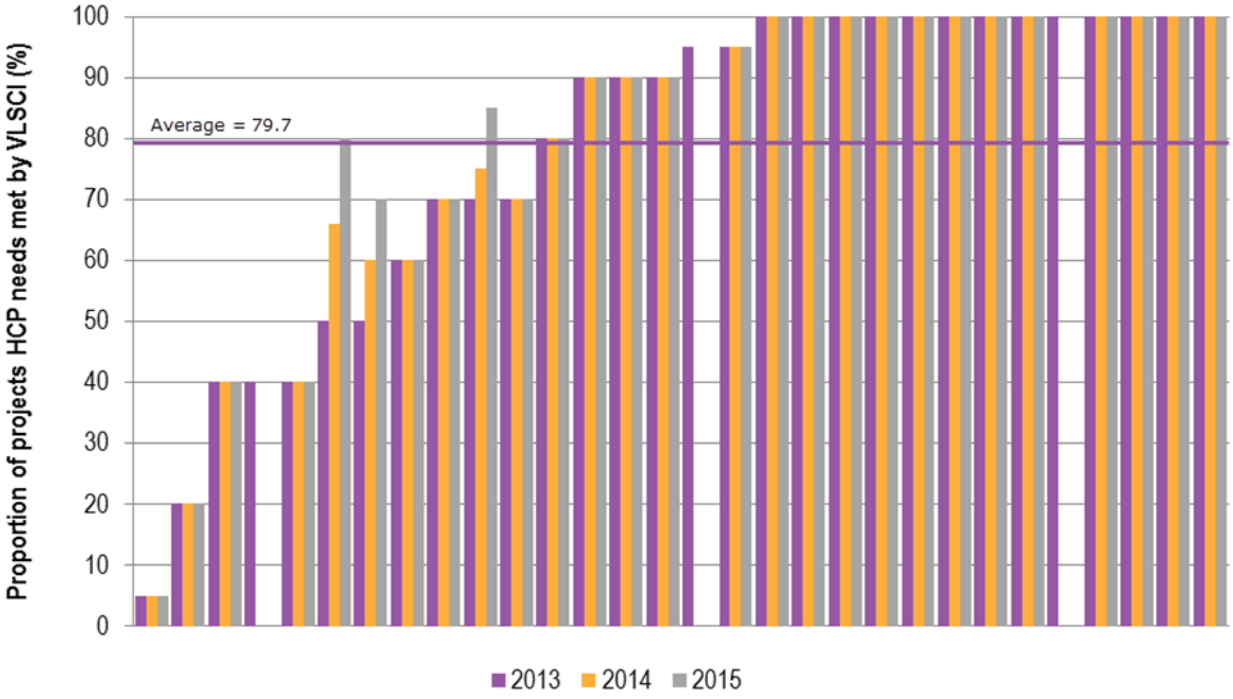


SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES

Survey respondents expected to have similar levels of utilisation of VLSCI between 2013 and 2015. Twelve respondents expected VLSCI to meet all their HPC needs in

2013, 2014 and 2015. Three respondents expected that their need for VLSCI computing resources would increase between 2013 and 2015, while 24 respondents expected that their VLSCI needs would remain the same across the three years. The three-year average for future HPC needs likely to be met by VLSCI is slightly higher than that reported for 2012 (79.7 per cent) (see Figure 11).

FIGURE 11 **PROPORTION OF HPC NEEDS EXPECTED TO BE MET BY VLSCI IN 2013, 2014 AND 2015**



SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES

Of the 2012 VLSCI projects, most respondents indicated that they used additional HPCs in the course of their project in addition to using VLSCI facilities, such as:

- six respondents used unspecified VPAC facilities,
- three specified that they used Monash University's "MASSIVE" system
- thirteen respondents used NCI facilities
- two respondents used iVEC facilities
- eight respondents said they used HPC facilities at Monash University
- one respondent used La Trobe University's HPC facilities
- seven respondents used other unspecified Australian HPC facilities
- four respondents used overseas HPC facilities.

Of the other HPC used by VLSCI projects, NCI and iVEC are included in the latest *Top500* rankings. In addition to these facilities, as discussed in Section 2.5.2, there are other supercomputers in Australia. The capabilities of these supercomputers are listed in Table 10.

ACIL Allen understands that before the arrival of the BlueGene/Q, available computer time was fully allocated. It appears that, in this period, the RAS Committee sought to maximise the number of research groups who could access the facility and some groups' requests for time were scaled back. The BlueGene/Q increased

capacity by a factor of twenty and the RAS Committee has now adopted an approach where the amounts of computing time requested are largely based on the level of justification provided by the researcher.

With over 240 licensed software applications that are specifically designed to meet the needs of computational biologists installed on VLSCI systems, there is clearly a wide range of software and tools available to researchers using the PCF. Our consultations did not identify any researcher who believed that the VLSCI facilities were lacking in this area.

TABLE 10 **CAPABILITIES OF AUSTRALIA'S TOP SUPERCOMPUTERS**

Installation site	Manufacturer & Computer name	Applications
NCI, ANU	Fujitsu – 'Raijin'	Weather and climate modelling, computational chemistry, particle physics, astronomy, material science, microbiology, nanotechnology, photonics
VLSCI, Melbourne	IBM – 'Avoca'	Life sciences
CSIRO	Xenon – 'CSIRO GPU Cluster'	Computational biology, climate and weather, multi-scale modelling, computational fluid dynamics, computational chemistry, astronomy and astrophysics, computational imaging and visualisation, advanced materials modelling, computational geosciences
NCI, ANU	Oracle - 'Vayu'	Scheduled to go out of service in September 2013.
Department of Defence	IBM	Unknown
iVEC	HP	Radio astronomy, geoscience
Digital Content Provider	HP	Unknown

SOURCES: http://www.csiro.au/portals/publications/brochures--fact-sheets/gpu-cluster.aspx ; http://www.fujitsu.com/au/news/pr/archives/2013/20130731-01.html ; http://www.news.uwa.edu.au/201202074317/events/new-supercomputer-help-scientists-reach-stars

While a clear majority of researchers using the VLSCI's computers have had the vast bulk of their needs met through those facilities, there is clearly scope for those who don't have their needs fully met to use other computing facilities. However, that option may not be practical in all cases. Other HPCs may not be suitable for a number of reasons. These include having insufficient time available for allocation to new users, not being configured (in terms of hardware) or the necessary software is not available.

In other cases accessing other HPCs may not be a practical or accessible option for geographical reasons. One stakeholder noted that while similar facilities did exist elsewhere in the world for this researcher, the large amount of data involved in the research being undertaken would make data transfer to an overseas facility impractical.

Several stakeholders commented that the ability to access the skills within the LSCC helped reduce the 'start up barriers' for life sciences researchers who were new to supercomputing and did not possess the necessary skills within their research group (e.g. bioinformatics or computing), to design their own research projects that used the PCF. They argued that larger research groups (who tend to have more in-house specialists) find it much easier to gain access to supercomputer facilities.

5.2.3 Demand and Accessibility

The 2010 Annual Report stated that, within less than a year of beginning operations, the demand for time on the VLSCI supercomputers exceeded the time available. As a result many of the research groups began to have their allocations of time reduced below the amounts requested in their applications, notwithstanding the fact that the applications were of a high quality.

Demand for computing time has largely increased in parallel with the computing capacity of PCF. By 2011 the VLSCI was 50 per cent oversubscribed in terms of the applications for resource allocation for the year.

At the end of 2012 the VLSCVI offered 15 per cent of the time on the BlueGene/Q for allocation through the National Merit Allocation Scheme call for resources to be used in 2013. This move was a first step by VLSCI towards meeting a commitment to broaden its reach and contribute to national computational infrastructure.

In 2012 the VLSCI had 560 users from 28 institutions. The vast majority of users were from Victoria. The largest user of the VLSCI's computers was the University of Melbourne, with 210 users identified as belonging to that institution. Only 35 users were identified as being from non-Victorian universities or other non-Victorian groups. Thirty users were identified as gaining access through the national allocation scheme.

A number of stakeholders commented on the Resource Allocation Scheme. The tenor of the comments was generally around the need for changes in how the RAS operates.

The existing approach for allocating time on the computers was criticised by a number of stakeholders. They argued that the process is skewed towards "trying to please everybody". This is done by reducing allocations of time below the amount requested in order to allow more applicants to use the facility. The challenge for the VLSCI is that the RAS peer review process is regarded as a strong one and it is difficult not to accept the peer reviewed recommendations.

Some stakeholders emphasised the need to identify and prioritise high quality projects. Stakeholders commented:

> …more could be done to support the larger, and perhaps, more 'visionary projects' being undertaken by Victorian researchers. (There are) too many micro projects with limited scientific horizons receive funding from VLSCI.
>
> … it might be a good time to revisit the mission of VLSCI to better signal a focus on cutting edge or innovative research.
>
> (VLSCI) needs a 'flagship project', the kind of project that might be on the cover of Nature.
>
> … a change in vision to support larger more cutting edge research projects, over smaller projects would help boost the quality of science being delivered through VLSCI

Several stakeholders argued that the VLSCI should continue to move towards a more national approach in how it allocates time on its computers. This was seen as an important element in both broadening its user base and providing greater opportunities to access national sources of funding for research infrastructure.

One stakeholder believed that the allocation process could move from twice a year to four times a year. They argued that this would provide more flexibility to researchers seeking access to VLSCI resources. The current time between allocation rounds can hold up worthwhile projects by as much as six months.

5.2.4 Contributions

The level and source of contributions to the VLSCI are discussed in section 5.1.1. Cash and in-kind contributions are currently being received only from Victorian institutions. The sources of the contributions have been largely constant over the life of the VLSCI.

With the exception of IBM, we are not aware of any private sector contributions to the VLSCI. The in-kind support provided through the staff within the IBM Collaboratory is undoubtedly important. Half this team works directly on the PCF (in particular, the BlueGene computer), while the other half work with Melbourne-based

researchers (mainly at the University of Melbourne). Comments made about the Collaboratory include:

> VLSCI gets things out of the relationship with IBM over and above what they are paying for. In particular, assistance in developing project designs that help researchers to solve their 'problems'.
>
> IBM's support for life sciences through VLSCI is a unique contribution. The physical sciences and engineering have been using computers for decades but computing is relatively new to life sciences and the support provided by IBM is needed by researchers.

Increased private sector involvement in, and support for, the VLSCI would undoubtedly help ensure the sustainability of the facility. However, achieving such an outcome will be difficult. The best prospects for doing so are probably through the normal process of translating promising research results into commercial products. We have identified a number of projects that have potential promise in this regard (see Appendix C). However, commercialisation of medical research normally takes considerable time, and private sector interest is only just beginning to emerge for a small number of projects. Consequently, funding for the operation of VLSCI is likely to need to come from the public and research sectors for some time.[33]

5.2.5 Customer service

The VLSCI provides a number of mechanisms for its users to seek assistance in addressing any problems that arise during their use of the PCF. The responses to the user satisfaction surveys carried out by VLSCI demonstrate that researchers rank the support they receive very highly. The results of those surveys are discussed further in section 5.4.3. They support the view that the VLSCI is performing well against this indicator.

5.3 LSCC's performance against its KPIs

The LSCC is assessed against the following four indicators:

- **Achievements**. Performance against this indicator is measured in terms of key research achievements obtained by the LSCC projects and significant developments facilitated by the LSCC.
- **Participation**. Performance against this indicator is measured in terms of the profile of projects supported by the LSCC and participation and contribution of organisations in the LSCC.
- **Capability**. Performance against this indicator is measured in terms of the number of specialists and their host organisations in the LSCC core pool, the extent and profile of skills in the LSCC core pool and the kinds and capability of services delivered by the LSCC.
- **Researcher satisfaction**. This is measured through the results of surveys of the level of researcher satisfaction.

5.3.1 Achievements

There has been a significant growth in the number of FTE staff working for LSCC. Between 2010 and 2013 the number of full time equivalent (FTE) staff has increased from one to 18. The bioinformaticians within LSCC, and the training provided by them, mean that Victoria now has a significant concentration of people who are

[33] VLSCI has estimated that some $9 million a year is required for the operation and maintenance of the facility. This does not include funding for replacement of the supercomputers.

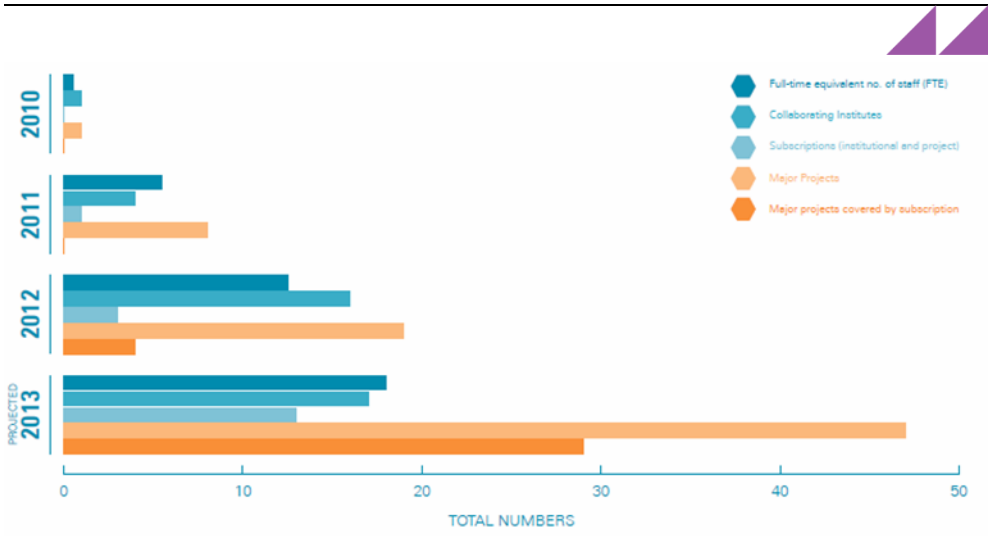
highly skilled in bioinformatics and related disciplines. Stakeholders have suggested that this is a resource that is unrivalled in Australia.

Other achievements of LSCC identified in VLSCI's 2012 Annual Report include:

- Significant growth in the number of collaborating institutions. From a small base of the largely confined to the University of Melbourne in 2010, LSCC now has connections with institutions across Victoria and Australia which span the university and research sectors and the non-government sector.
- Growth in the number of institutional subscriptions for LSCC's services and support. Further analysis of this is provided in the section that discusses researcher satisfaction below. These subscriptions are also supporting an increasing number of large research projects.
- A significant expansion of LSCC's role in major research projects being supported by VLSCI. This demonstrates that LSCC is not only providing entry level support and advice to researchers, but also playing a significant role in helping to shape the outcomes of some of the large, cutting edge, research ventures that use VLSCI's facilities.

These achievements are consistent with feedback gained from consultations with a broad range of stakeholders. As such they provide an indication that LSCC is performing well against this indicator.

FIGURE 12 **ACHIEVEMENTS OF LSCC 2010-2013**



SOURCE: VLSCI 2012, ANNUAL REPORT, VLSCI

LSCC supported research is delivering excellent results. For example, a joint project by Monash and University of Melbourne researchers examining multiple antibiotic resistant bacteria is pointing the way towards changes in clinical practice that could generate significant patient health benefits.

Another research group is using the supercomputer at VLSCI to model the way that enzymes in antibiotic resistant bacteria move. They hope to use that information to develop drugs that disrupt those movements.[34] One of the lead researchers for this project commented that:

> The reality is it's probably more than a billion dollars to develop an antibiotic and approximately 20 to 25 years (of research), but with a supercomputer we can drastically reduce that time of

[34] http://www.abc.net.au/7.30/content/2012/s3411750.htm, accessed on 11 November 2013.

> discovery. … and reduce the time it takes to discover that drug by potentially up to 50, 60, 70, maybe 80%.

5.3.2 Participation

Life sciences research groups have to deal with increasing amounts of data who want to take advantage of VLSCI's supercomputers to reduce the time needed to for their research to deliver results. LSCC can help ensure that researchers make the best possible use of the VLSCI's supercomputing facilities. This might include telling researchers that they do not need to use a supercomputer to solve their particular research problem. In some cases, LSCC can also assist researchers to design pilot studies to enable them to test whether use of the PCF will assist them to meet their research goal. One stakeholder stated that this:

> … saved research labs hundreds of thousands of dollars by helping them to identify pilot projects to test ideas

In essence, LSCC helps to reduce the 'barriers to entry' that life sciences researchers face. Particularly researchers who are new to the use of supercomputers in their field and don't have the necessary skills (such as bioinformatics or computing) within their research teams.

One of the problems is that some of the life sciences research groups may only need half a bioinformatics expert. While they can ask for funds for 0.5 FTE bioinformatics expert, it is much more difficult to hire less than 1.0 FTE. LSCC helps them to get around this problem. Research groups can pay a subscription and then access skilled people to the extent that they need them.

In addition, by providing access to the PCF through its block grant of computing time the LSCC reduces the transaction costs for smaller researchers that would otherwise have to go through the normal resource allocation process. Through the provision of these services the LSCC helps to ensure the efficient use of the PCF by researchers.

LSCC staff can also offer assistance with research design, software and hardware choices and work flow planning. In 2012-2013 LSCC:

- Provided support to 35 discrete research projects, covering a wide range of research fields within the disciplines of biological and life sciences.
- Provided support to projects of varying size and scale. The projects outlined in the table are a mixture of small, medium, and large projects, which means they provide support to all types of researchers, operating at all stages of their careers.
- Worked with research leaders from a wide range of research institutions. LSCC staff supported researchers from 16 different research institutions. This includes universities, medical research institutes, hospitals, research centres, and privately owned or non-government research organisations.

However, LSCC is clearly more than just a supporter or provider of expertise to other researchers. Our consultations have shown that LSCC staff are active participants at all stages of the research process. In several cases they are the leaders of research projects. Table 11 lists the research projects and their host institutions that are currently supported by LSCC staff and resources.

We believe that the LSCC is performing well against this indicator.

TABLE 11 **CURRENTLY SUPPORTED LSCC PROJECTS**

Project name	Host institution
Development of Molecular Dynamics Drug Docking	Monash University
Modelling pore-forming toxins	St Vincent's Institute
Molecular Modelling of Novel Enterovirus Proteins Associated With Acute Flaccid Paralysis	Victorian Infectious Diseases Laboratory
Molecular modelling of plasma albumin for development of brain drug delivery	University of Melbourne
Targeted sequencing of a myopia linked gene region to identify disease associated changes	Centre for Eye Research Australia
The role of genetics and epigenetics in the development of Multiple Sclerosis	The Florey Institute of Neuroscience and Mental Health
Integration of biological data and mining them to obtain novel biological insights	La Trobe University
Stress transcriptomics: development of tests to reduce the incidence of summer mortality in abalone	La Trobe University
Pipeline for polymorphism mapping in parasitic nematodes	La Trobe University
Proteomics of the Apple scab fungus	La Trobe University
Unravelling the genetics of common epilepsies	Melbourne Brain Centre
Assembly and annotation of all bacterial genomes in the NCBI Sequence Read Archive	Monash University
Targeting macrophage subtypes as a strategy for chronic inflammatory lung disease therapy	Monash University
Comparative genomics and transcriptomics of Babesia parasites	Monash University
Registration of CT and MRI images for advanced segmentation and visualisation of anatomy	Monash University
Measurement and prediction of vulnerable plaque formation and rupture	Monash University
Imaging the process of life	Monash University
3'-Seq: a novel method for quantitative analysis of gene expression in eukaryotic transcriptomes	Monash University
Understanding antibiotic resistance in *Acinetobacter baumannii*	Monash University
Comparative genomics to decode Lipopolysaccharide diversity in Leptospira	Monash University
Investigation of mobile elements in Clostridium difficile	Monash University
Genomic analysis of mobile elements from pathogenic Clostridium perfringens	Monash University
Identification of Pasteurella virulence genes and vaccine antigen candidates	Monash University
Genomics for persistence of Australian freshwater fish	Monash University
Genome wide DNA methylation profiling of Childhood B-Cell Acute Lymphoblastic Leukaemia	Murdoch Children's Research Institute
Deciphering the functionality of genetic data through integrative bioinformatics approaches	Peter MacCallum Cancer Centre
Identification of breast cancer predisposing genes using genome sequencing	Peter MacCallum Cancer Centre
VCCC Human DNA Variation Repository	Peter MacCallum Cancer Centre
Bioinformatics for EMP-associated gene expression and EMPathy Target Discovery data integration	St Vincent's Institute of Medical Research
A description of the intestinal bacterial community of the premature infant	The Women's Hospital
Pathogen Genomics and Genetics Program	University of Melbourne
Targeted sequencing of ESR1 and other hormone metabolism genes and risk of breast cancer	University of Melbourne
Transcriptome profiling of glioma stem cells: subtype analysis and molecular target discovery	University of Melbourne
Cancer Predisposition Genes Identification	University of Melbourne
Determining the molecular profile of lethal prostate cancer	Royal Melbourne Hospital
Genomic and Transcriptomic Characterization of Micropapillary Adenocarcinoma	St Vincent's Hospital
Using comparative bacterial genomics to address issues in clinical microbiology	University of Melbourne

Using RNAseq to understand how Staphylococcus aureus Responds and Adapts to Antibiotics	University of Melbourne
Developing algorithms for biomarker identification in human cancer tissue sections	Victorian Cancer Biobank
Genetic and epigenetic effects of L-sulforaphane	Baker IDI
Sequence analysis of exosomal RNA	Bio21

SOURCE: VLSCI 2013, LSCC SUPPORTED PROJECTS, http://www.vlsci.org.au/lscc/lscc-supported-projects

5.3.3 Capability

Capability development is a core objective of LSCC's leadership team. To ensure it meets this objective, LSCC provides two main services, namely:

- Subscription services, including embedded services, community development services, grant-support services.
- A capability building program. Students and researchers from collaborating institutions are invited to join the LSCC one day a week for between three and twelve months as an in-kind contribution to the LSCC from collaborating institutions. Participants contribute to the pool of expertise and resources and transfer knowledge and experience back to their host institutions, while promoting participation in infrastructure research projects and interaction with other similar projects.[35]

Our consultations have highlighted the strong role that the LSCC has played in developing a pool of expertise and resources that is unparalleled in Australia. Prior to the establishment of LSCC, the level of bioinformatics expertise was insufficient to meet the emerging needs of Victoria's life sciences community in the fields of large genome diploid genomics, microbial genomics (i.e. bacteria, viruses and parasites), and variant detection, genotyping and annotation.

As part of their training program LSCC runs a course on theory every couple of weeks on average. They also prepare on-line training material that students can access to develop their practical skills in applying the theory to experiments. The courses are available to students in Australia and overseas. There is no charge for the training.

LSCC operates across three hubs (at Monash, Latrobe and Melbourne University). They meet weekly to discuss their work, any problems that arise and how to address them. The meetings are primarily for internal use, but guests (such as PhD or post-doctoral students) who might be seeking advice can also participate. One stakeholder described the activity as providing a 'brains trust'.

LSCC is also involved in an annual retreat run by VLSCI for practising bioinformatics experts. Each retreat involves about 70 Victorian researchers

Since the establishment of the VLSCI, and the launch of LSCC, a significant level of expertise in bioinformatics has been developed in Victoria. One stakeholder commented that the training of bioinformatics experts would not have been possible in Australia prior to the creation of the VLSCI.

LSCC's expertise has been built on the back of capability-building activities that include:

- Researching and documenting new approaches and tools for common activities.
- Devising and implementing research projects for evaluating tools, applications, and techniques and then interpreting and publishing the results of these projects. This is

[35] *2012 Annual Report*, VLSCI

contributing to a common knowledge base of best practice in the use of tools and techniques.

- Disseminating expertise and research outcomes to the research community through fortnightly capacity-building sessions and annual conferences for the exchange of ideas.[36]

It appears, from the consultations undertaken and the data examined during this review, that LSCC is playing a significant role in the development of core capabilities to support the effective use of VLSCI's supercomputing facilities by Victorian researchers.

We note that should VLSCI seek to continue to shift towards playing a more national role, then LSCC may need to consider the extent to which it is able to extend its reach to support life science researchers throughout Australia.

5.3.4 Researcher satisfaction

Given the breadth of support, across all stages of the research process, offered by LSCC, the overall levels of satisfaction are high. This is evidenced by the growth in institutional subscriptions since 2010. LSCC currently has 12 subscribing institutions, namely:

- Cancer Council Victoria
- Eastern Hill Precinct through the Department of Medicine at St Vincent's Hospital
- Monash Health Translation Precinct
- The University of Melbourne Centre for Translational Pathology
- The NeCTAR Genomics Virtual Laboratory
- The University of Melbourne Genetic Epidemiology lab
- Monash University Department of Psychology
- Monash University Central Clinical School
- The NeCTAR Endocrine Virtual Laboratory
- Monash University School of Biomedical Sciences
- La Trobe Institute of Molecular Sciences
- Melbourne Dental School – Oral Health CRC.[37]

Consultation with LSCC staff indicate that most subscribers have used LSCC's support to leverage other existing research funding, to attract new research funding, and to initiate new collaborations with national and international partners.

The large number of workshops and seminars facilitated by LSCC staff and attended by researchers also encourage collaboration. Section 3.4.1 discusses the training provided by the LSCC. This includes hosting a workshop or seminar approximately every 1.5 to 2 weeks. Estimated attendance figures at workshops provided to ACIL Allen suggest that the average attendance per workshop over the period 2010-2013 has been around 20 people.

While this is only an indication of satisfaction, the frequency of workshops and seminars and the high average attendance rate over a three year period is indicative of a high level of satisfaction amongst researchers about the quality of support provided by LSCC.

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[36] http://www.vlsci.org.au/page/research-support-services

[37] List of subscribers provided by LSCC.

We note that the large number of workshops provides supporting evidence for the view expressed during our consultations that LSCC has actively pursued a broad capacity development agenda for VLSCI.

5.4 Outreach function performance against KPIs

The outreach function of the VLSCI has four performance indicators. These are listed below along with the way in which their performance against the indicators was to be measured.

- **Achievements**. Performance against this indicator is measured in terms of the major achievements in the outreach program and each of its components (skills development and education, stakeholder and public engagement) and collaborations and industry uptake. Both the number and types of outreach activities conducted in each component will be considered.
- **Participation**. Performance against this indicator is measured in terms of the participation of people (number, organisation, location) in outreach activities, the participation of organisations in the program and their profile and contributions the extent and profile of people accessing the VLSCI website and its news service.
- **Contributions and satisfaction**. Performance against this indicator is measured in terms of the extent of the contributions from participants, stakeholders and sponsors, and the qualitative responses from attendees to the activities.

5.4.1 Achievements and participation

VLSCI's outreach activities are reported in their Annual Reports. It is evident that VLSCI has undertaken a diverse range of outreach activities including: exhibitions; skills development; publications; communications; presentations; grants; training; lectures; engagement; conferences; sponsorship; collaboration; and memberships.

Levels of participation in outreach activities are appropriate to the nature of each activity. The trends for activities such as web page visits and newsletter subscriptions are for increasing participation over time.

The extent of stakeholder satisfaction with individual outreach activities is unknown. However, based on the responses to the user satisfaction surveys done by VLSCI users think highly of these activities (see section 5.4.3). Furthermore, many of the stakeholders consulted in the course of this study indicated that they saw considerable value in the outreach activities undertaken by VLSCI (and LSCC). Stakeholder comments included:

> LSCC's weekly seminars were unique and an excellent way of delivering outreach for VLSCI.
>
> Outreach should continue to be an essential element of VLSCI's future activities. This was particularly the case if there was uncertainty surrounding funding, since outreach will be an important method for securing commercial funding and support. Outreach activities were also identified as serving an important role in ensuring VLSCI remains at the cutting edge of supercomputing infrastructure.
>
> VLSCI's outreach in terms of education is similar to the performance of the University of Illinois, which is seen as the global leader in this area.

A number of stakeholders suggested that there was an opportunity for VLSCI to expand its training role as a result of the experience it has gained to date.

5.4.2 Outreach activities

VLSCI conducts outreach activities under three broad categories:

- Stakeholder and public engagement

- Skills development and education
- Industry collaboration and uptake.

Activities undertaken in 2011 and 2012 in each of these categories are examined below.

Stakeholder and public engagement

The aim of VLSCI's stakeholder and public engagement program is to increase the awareness of the capabilities and benefits of the VLSCI, to promote (with the State Government and University of Melbourne) major events associated with the VLSCI, and to use the VLSCI website, and associated channels to promote VLSCI objectives, programs, grow awareness and generate interest.

VLSCI promotes its resources through a range of stakeholder and public engagement activities including: hosting delegations; presentations at conferences and events; delivering workshops; continuing the *Science Story* series; material in national and international media (for example China); and representation at conferences and other industry gatherings.

VLSCI also developed a media presence with several pieces appearing in industry/science journals, online and through national press. The media presence was also aided by a two stage media campaign in mid-2012 to coincide with the launch of BlueGene/Q.

Examples of some of the stakeholder and engagement activities undertaken in 2011 and 2012 are shown in Table 12.

TABLE 12 **STAKEHOLDER AND PUBLIC ENGAGEMENT ACTIVITIES**

Example of activities	Participation
2011 - Exhibition *Things Change When You've Got the Power* displayed at University of Melbourne during Festival of Ideas, Monash University for eXPO, John Monash Science School for their Science Fair (attended by over 800 people) and Gene Technology Action Centre as part of WEHI Bioinfosummer workshops.	Festival – 2000, Expo – 500, JMSS – 800, GTAC - 150
2011 - Announcement as joint primary sponsor of UROP.	UROP Conference Day attended by 100 students and state and federal MPs
2011 - Scaled up commitment to Undergraduate Research Opportunity Program (UROP).	10 half stipends per annum and $50,000 contribution to administrative costs of program over 3 years
2011 - Support for more UROP stipends than originally budgeted.	2 additional stipends
2011 - First mention in *Nature* magazine. Published in *Nature* online on 20 October 2011. Story covered by interview on *ABC Radio* and in *Australian Life Science*	Unquantified international and national audience. *Nature* has a JIF of 38.597.
2011 - Presentation at Forum meeting in June, sponsored a presentation in July and presentations by PhD students in December.	Over 40 attendants at each meeting.
2011 - *Science Story* No.6 published and featured in Federal Government publication *Stories of Australian Science.*	Distributed to: *Bio 2011* in Washington, 500 scientists, public servants and journalists at PM's Science Prize dinner, embassies and consulates, 1,500 Australian and international science journalists, 500 science stakeholders, 400 catholic schools, MPs.
2011 - Editorial and Science Story included in magazines that target business and government in China.	Not specified.

Example of activities	Participation
2011 - *Science Story* No.7 published.	Not specified.
2011 - Formal representation at *eXPO*, AusBiotech, eResearch Australasia (as well as three presentations), *SC11, Bioinfosummer*.	Not specified.
2011 - Hosted delegates from AusBiotech Business Development workshop.	10 industry visitors
2011 - Presentation on opportunities to work and study in computation biology.	150 international students.
2011 - Featured in material aimed at bringing together women in technology.	Distributed to over 400 attendees of BioMelbourne Network lunch.
2011 - Sponsorship of the *ICT for Life Sciences* Forum and the annual *Graeme Clarke Oration.*	1,800 lecture and 1,000 dinner attendants.
2011 - Promotional video launched for *Festival of Ideas* and at *Bio 2011* in Boston. A second video was produced for use at conferences and presentations.	Not specified.
2011 - Outreach to careers teachers in Victoria and international marketers about skills shortages in computational biology.	via University of Melbourne, Faculty of Science
2011 - Contributed to presentation.	50 members of Melbourne Linux Users Group
2011 - A/Prof. Andrew Lonie presented to University of Melbourne's Department of Pathology.	50 (estimated)
2011 - Prof. Justin Zobel presented a public lecture on Computational Challenge of the $100 genome at the Royal Society of Victoria.	85 members of the general public
2011 - Sponsored a presentation to students attending University of Melbourne's *Summer Science Experience*.	95 students in year 10.
2011 - Sessions to VCE biology teachers.	60 teachers
2012 - VLSCI staff delivered seminars and made presentations at 31 national and international events. Locations included Melbourne, Kuala Lumpur, Jakarta, Singapore, San Diego, Bangkok, Brisbane, Chicago, Spetses (Greece), Adelaide and Sydney.	Not specified
2012 - Hosted a delegation from Jiangsu Province in China.	23 visiting officials.
2012 - Increases in total visitors, unique visitors, page views and average visits per day. Most visited pages were software and documentation, LSCC resources, training courses, news and opportunities.	14,769 unique visitors to the website. 31,082 total visitors to the website.
2012 - Increase in eNews subscriptions from 450 in 2011 to 550 in 2012.	150 new subscribers.
2012 - Twitter account established as a social media vehicle through which to contact users and stakeholders about systems news and to learn about outreach activities.	Over 120 followers
2012 - VLSCI provided different levels of sponsorship to conferences and workshops. These included sponsorship of *Lorne Conferences, Genetics Society of Australasia, Graeme Clark Orations* and *M4*, as well as several smaller events.	Combined 4,379 participants attended these events.
2012 - *Science Story* Nos. 8 and 9 published.	Not specified.
2012 - Half stipends paid to UROP student projects with a focus on computational biology.	14 new students, 19 in total for 2012
Examples of media in 2011 and 2012: Scientific Computing World - Prof. Taylor Nature Genetics – Kathryn Holt Various ABC Outlets – Prof. Mark Cooper Major publicity campaign to announce arrival of BlueGene/Q 2nd stage media campaign on how researchers were working with Biota Holdings Ltd Australian Financial Review – VLSCI Director	Not specified

SOURCE: VLSCI ANNUAL REPORTS AND QUARTERLY OUTREACH REPORTS

Skills development and education

The aim of VLSCI's skills development and education program is to increase the skills of users and support staff of the LSCC and PCF, provide undergraduate and postgraduate study assistance, support young researchers through an internship program, support the broader education agenda in computation and its applications, involve educators in the development of courses at undergraduate and post-graduate levels, and develop learning materials.

VLSCI promotes its resources through a range of skills development and education activities including: meeting and expanding its commitments under UROP; holding information sessions on different aspects of VLSCI's operations; and supporting students and researchers by providing travel grants to conferences and events.

Examples of some of the skills development and education activities undertaken in 2011 and 2012 are shown in Table 13.

TABLE 13 **SKILLS DEVELOPMENT AND EDUCATION ACTIVITIES**

Example of activities	Participation
2011 - To attend *Early Adopters PhD Workshop* at SC11 in Seattle.	Seven grants awarded to Victorian PhD students.
2011 - Scaled up commitment to UROP.	10 half stipends per annum and $50,000 contribution to administrative costs of program over 3 years
2011 - Support for more UROP stipends than originally budgeted.	2 additional stipends
2011 - Lecture to Master of Computing course on High Throughput DNA Sequencing by Dr Bernard Pope.	100 (estimated)
2011 - Hosted Katie Sharp, NZ, lecturing on A Mathematical Model of Fluid Transport in the Lung as part of the IBM Research Collaboratory Seminar Series at the University of Melbourne.	100 (estimated)
2011 - Travel and support grants developed.	Five grants awarded to Victorian students.
2011 - Workshop on NAMD software on the Blue Gene	20 VLSCI staff and associates attending.
2011 - HPC basics	25 attendants.
2011 - Workshop on Intellectual Property and dealing with VLSCI.	Over 40 attendants.
2011 - Sponsored a Live Cell Imaging workshop. Follow up workshop in 2012.	28 attended.
2011 - LSCC workshop on Hands-on introduction and RNA-seq analysis	18 researchers.
2012 - VLSCI offers work experience opportunities to interested secondary students.	1 work experience place awarded.
2012 - VLSCI supported research attracted several international PhD students; at least 16 local MSc or PhDs; and 14 post-doctoral researchers.	At least 30 researchers.
2012 - VLSCI delivered and supported training courses for new and established computational biologists.	At least 622 people attended training courses offered by VLSCI, with a mix of international and Australian audiences.
2012 - PhD top ups	17 top ups awarded for up to a 3 year period.

SOURCE: VLSCI ANNUAL REPORTS AND QUARTERLY OUTREACH REPORTS.

Collaboration and industry uptake

The aim of VLSCI's collaboration and industry uptake program is to promote the use of the LSCC and PCF, particularly by industry, and plan for engagement with companies through a series of pilot projects. It also aims to strengthen collaborations amongst the broader VLSCI community and with national life sciences community including NCRIS supported organisations, and to develop workshops focussing on life sciences applications and innovative technologies, and to encourage students and young researchers to attend international forums and events.

VLSCI promotes its resources through a range of collaboration and industry uptake activities including: enabling communication between LSCC hubs; hosting interns at LSCC; working with participating universities to promote the facilities; and promoting travel to local and international events with the requirement that researchers share lessons with the life sciences community on their return to Victoria.

Examples of some of the collaboration and industry uptake activities undertaken in 2011 and 2012 are shown in Table 14.

TABLE 14 **COLLABORATION AND INDUSTRY UPTAKE ACTIVITIES**

Example of activities	Participation
2011 - Installation of audio visual equipment that facilitates communication between LSCC hubs at La Trobe, Monash and Melbourne Universities	Used for fortnightly bioinformatics meetings with over 20 attendants.
2011 - Workshops to bring together life science and computer science post graduates.	Over 50 attendants.
2011 - LSCC interns	Eight internships awarded.
2011 - LSCC and VLSCI top up scholarships	Nine scholarships awarded.
2011 - Support for students in the University of Melbourne's MSc Bioinformatics course through $5,000 bursaries, places at Genetics Society of Australia conference and included in VLSCI subscriptions to AusBiotech.	Six bursaries awarded.
2011 - Inclusion in University of Melbourne's Faculty of Science corporate brochure which is sent to industry to encourage engagement.	Not specified.
2012 - VLSCI supported travel for training and/or conferences for computational biology researchers and students to attend a range of international and Australian events. Awardees are obliged to return to the community and share what they have learned.	20 researchers were awarded travel/conference grants.
2012 – Contributing to sustainability planning through preparation of industry materials for industry collaboration	Not specified
2012 – Providing a travel grant for Jason Roberts to attend a workshop on computational biophysics in the USA, with numerous collaborations resulting from the visit.	Not specified

SOURCE: VLSCI ANNUAL REPORTS AND QUARTERLY OUTREACH REPORTS.

5.4.3 User satisfaction

Researchers using VLSCI facilities are supported by a suite of resources that guide and support them with their HPC needs. According to the VLSCI website:

> To help researchers maximize their use of compute time and get the most out of their allocated resources, the PCF has a team of skilled system administrators, programmers and application specialists accessible through its help request system. Our experts also regularly update user documentation in response to new issues, software licencing and system changes.[38]

The complex nature of VLSCI facilities means that administration and administrative support is vital to the ability to conduct research using the facilities. These administrative resources enable benefits simply by guiding researchers and maintaining the computing resources. It could be argued that without these resources, researchers would not realise the potential of VLSCI and not realise many of the benefits previously identified.

Respondents were asked to rate the quality of various supporting resources of VLSCI (on a scale from one to five). The average ratings for the various resources are recorded in Table 15. Respondents were very positive about the support resources, which has resulted in most average ratings in excess of four ("very good"). The lowest average ranking was 3.92 ("adequate") which was awarded to training and education in 2011; however this improved to 4.06 in 2012.

TABLE 15 **AVERAGE QUALITY RATINGS FOR VARIOUS ADMINISTRATIVE FUNCTIONS OF VLSCI**

Year	Email help service	Web content for technical help	Training and education	Communication
2011	4.70	4.27	3.92	4.45
2012	4.63	4.00	4.06	4.26

Note: For all administrative functions (except 'Resource allocation) 5 = Very good, 4 = Good, 3 = Adequate, 2 = Poor, 1 = Very poor. No response and 'Not applicable' are not included in the average measure.

SOURCE: 2011 AND 2012 ANNUAL REPORT SUMMARIES.

Based on our analysis and consultations with stakeholders we believe that VLSCI's outreach function is performing well against its three indicators.

[38] Retrieved October 2013, from: http://www.vlsci.org.au/page/about

5.4.4 Value of VLSCI to users

The use of high speed computers in many fields of science is not new. However, their use as a tool in the field of life sciences is a more recent phenomenon, but one that is increasingly seen as indispensable for the modern day researcher. This was recently nicely demonstrated when, in announcing the 2013 Nobel Prize for Chemistry, the Royal Swedish Academy of Sciences stated that:

> Today the computer is just as important a tool for chemists as the test tube.
>
> Computer models mirroring real life have become crucial for most advances made in chemistry today.

As part of the same announcement the president-elect of Britain's Royal Society of Chemistry reinforced this message, noting that:

> The field of computational modelling has revolutionised how we design new medicines by allowing us to accurately predict the behaviour of proteins.

Some of the respondents to the 2012 VLSCI user survey referred to the importance of supercomputers to their projects. Responses included:

> …[this] problem is solvable only on a supercomputer. Consequently VLSCI has been indispensable for the analysis of this important problem that is being pursued by several groups worldwide…
>
> …While other [project] aims could have been met without HPC, the time required would have increased near tenfold. For these aims, the extra computational grunt have [sic] allowed fast, accurate research, keeping us competitive with international research groups…
>
> …The supercomputing facility and the software resources provided by the VLSCI helped us perform our research and deliver high quality timely results, with convenience…
>
> …On commodity computers these [cardiac modelling] simulations would require weeks to simulate a heartbeat. The IBM Blue Gene/Q Avoca allows us to simulate a heartbeat within hours. This is important since we want to carry out studies where we model minutes of real time as well as carry out parameter search as well as test robustness of the model. Without this compute resource, we would not be able to carry out the research…
>
> …The VLSCI has enabled us to carry out investigations of the neural structure in the retina that would not be possible on a conventional computer system…
>
> …The large number of CPUs and interconnect provided on Merri has enabled several projects that would be otherwise very difficult on other resources…
>
> … The simulations I need to carry out to achieve my research outcomes are so massive, there are very few platforms I could run them on - in this sense the VLSCI is a capability computing resource for my work…

6 The way forward

Throughout the course of this review, ACIL Allen has identified a number of ways in which VLSCI might evolve as it seeks to consolidate its achievements to date. The objectives of this evolution are

- further enhancing the scale of benefits arising from VLSCI
- consolidating and growing the effectiveness of its support for life sciences research
- improving its longer term sustainability.

There are three main elements to the proposed evolution of VLSCI, namely:

- improving the linkages between VLSCI and Victorian Government priorities
- expanding access to VLSCI's resources, facilities and expertise. This includes:
  - reviewing the VLSCI's strategy
  - redefining the role of the LSCC
- improving governance arrangements.

Each of these elements is discussed below.

This section also provides a number of suggestions for how future evaluations might be improved to ensure that the necessary information about the benefits delivered by VLSCI are better captured.

6.1 Improving the linkages between VLSCI's objectives and the priorities of governments

As was discussed in section 5.2.4, support for the operation of VLSCI is likely to be dominated by funding from the public sector for some time to come. To improve its chances of being able to access funds from the Victorian and Commonwealth Governments VLSCI needs to ensure that there is good alignment between its objectives and those of these governments.

The need to improve these linkages between VLSCI's objectives and those of the Victorian and Commonwealth Governments was a theme that emerged through a number of our consultations with stakeholders. In particular, stakeholders believe that the key to the future sustainability of VLSCI lies in its ability to transition from a largely state-based facility to one that has a national focus. In other words, to position itself as a provider of research infrastructure that supports researchers across the whole of Australia.

To do this VLSCI needs to clearly demonstrate how its activities would contribute to achieving the Victorian and Commonwealth Governments' objectives, plans and priorities.

The Victorian Government's *Technology Plan for the Future – Biotechnology* has articulated a vision for Victorian life sciences that is based on:

- capability development, which includes:
  - world-class R&D
  - skilled and innovative people
  - pursuing international trade and investment opportunities

- biotechnology-enabled innovation
  - demand driven product development
  - linking industry to capability
- improving competitiveness.

The introduction to the plan by the Premier and the Minister for Technology states that the plan:

> … reflects the sector's desire for better collaboration between biotechnology innovators and industry, and for greater coordination of policies, activities and investment related to biotechnology.

It is this desire for 'better collaboration' and 'greater coordination' that should underpin the evolution of the VLSCI over the coming years. That is not to say that the VLSCI can necessarily deliver on all of the government's desired objectives on its own. The VLSCI's activities are of course already helping to deliver some of the elements of the plan (such as skilled and innovative people and world class R&D). However, VLSCI should be thinking about how it can enable and encourage other groups such as the private sector to collaborate with it to help deliver other objectives of the plan.

A future funding agreement between the Victorian Government and the VLSCI should reflect the Victorian Government's priorities. It will allow VLSCI to start planning for and delivering benefits that directly relate to the priorities of the Government. By better demonstrating how VLSCI is adding value to the State of Victoria it will also provide a more compelling case for continued Victorian Government funding and support. Where the objectives are differ, there needs to be a strong rationale included into the funding agreement as to why this is so.

In section 5.2.3 we discussed the need for VLSCI to have a strategy for identifying and prioritising high quality projects ('flagship' projects). Such projects have the potential to not only deliver cutting edge and visionary research outcomes but also help capture the global attention of the life sciences sector, including businesses that are looking for their next commercial opportunity.

Many of the stakeholders consulted for this project have also highlighted the need for VLSCI to become a national facility. As a national facility VLSCI should have a mandate to attract researchers from other jurisdictions that are currently excluded from having direct access to its facilities. Many of these stakeholders identified the potential additional funding opportunities for VLSCI that such a national approach would bring. The expanded reach of the facility would further enhance Victoria's reputation for world class life sciences research. Over time, such an expansion would be a positive factor in efforts to attract new firms and additional investment to Victoria.

However, in order to attract national research funding VLSCI will need to align itself more closely with the Australian Government's research, research infrastructure and innovation priorities. These priorities are listed in Box 2.

BOX 2 **NATIONAL STRATEGIC RESEARCH PRIORITIES AND INNOVATION PRIORITIES**

The Australian Government's Strategic Research Priorities (2012) are:

- Living in a changing environment: Research outcomes will identify strategies to develop resilient natural (ecosystems) and human environments (people, communities and their utilities and industry) that can all thrive in a changing environment.
- Promoting population health and wellbeing: Research outcomes will help to build resilient communities and achieve a state of physical, mental and social wellbeing, and not merely the absence of disease, or infirmity, for all Australians in whichever part of Australia they live.
- Managing our food and water assets: Research outcomes will identify new food production practices and systems that can accommodate competing demands for soil and water while ensuring the long-term sustainability of these assets.
- Securing Australia's place in a changing world: Research outcomes will identify ways to improve Australia's capacity to deliver national security and identify the means by which personal security in Australia will be safeguarded. This challenge should be considered in the context of global uncertainty and changes in the Asia Pacific region.
- Lifting productivity and economic growth: Research outcomes will identify the challenges and opportunities in a changing world economy, particularly in the context of the economic rise of Asia, and help to build a resilient new economy so that Australia can thrive, while also identifying the means to enhance the wellbeing of all Australians.

The Australian Government's National Innovation Priorities (2009) are:

- Priority 1: Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.
- Priority 2: Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.
- Priority 3: The innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development.
- Priority 4: More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises.
- Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.
- Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development.
- Priority 7: The public and community sectors work with others in the innovation system to improve policy development and service delivery.

SOURCES: 'DIISRTRE 2012 'STRATEGIC RESEARCH PRIORITIES' http://innovation.gov.au/research/pages/strategicresearchpriorities.aspx ; DIISR 2009, 'POWERING IDEAS' http://www.innovation.gov.au/

As is the case with Victoria's priorities, it is not possible (or appropriate) for VLSCI to directly address all the Commonwealth Government's research priorities. VLSCI's focus will clearly be on the research priority for *promoting population health and wellbeing*.[39] There is more scope for VLSCI to demonstrate its alignment with national innovation priorities. Even so, alignment with innovation priorities 3, 5 and 6 will be more difficult. However, as discussed above in relation to Victoria's priorities, there is scope for VLSCI to demonstrate its capacity to contribute towards these priorities in the future.

6.1.1 Better linkages – potential implementation measures

The specific measures that VLSCI could adopt that, if implemented, would support this element of the evolution of the VLSCI include:

- Clear articulation how they will support the Victorian government's objectives

[39] However, VLSCI supported research will help us understand and address issues across the economy, such as the effect of climate on our food supplies, abundance of species and what food supplies we can exploit. Life sciences computation can also play an important part in strengthening our national security. For example, identifying and addressing the threats of pandemics and improving our resilience against bioterrorism.

- Developing performance measures that demonstrate progress towards those objectives and monitoring and reporting against these. In doing so it will be important for the Victorian government and VLSCI to agree:
  - that the measures capture the objectives and intent of the Government's technology plan
  - that data is available to monitor performance against the indicators
  - that collection of that data is feasible and efficient
- Clear articulation of how VLSCI will support the (relevant) national research priorities and national innovation priorities
- Developing performance measures that demonstrate progress against these priorities and monitoring and reporting against these

As discussed above, one element of how the VLSCI could deliver against the priorities and objectives of the Victorian and Commonwealth Governments would be to continue and expand its strategy to identify and prioritise high quality projects ('flagship' projects). This may require evolutionary changes to the terms of reference for the Resource Allocation Scheme Committee to implement this approach. It will also be important that researchers are aware of changes to the strategy for determining which projects receive time allocations on the PCF and the reasons for those changes.

We do not suggest that time on the PCF should solely be allocated to large, high impact projects. Some allocation should be retained for smaller projects that might come forward with an innovative approach or idea. The LSCC could be the gateway for such projects to access this allocation of time on the PCF. This is discussed further below.

The flip side of placing greater emphasis on larger high impact projects is that the results delivered by these projects should be more closely monitored. If the results suggest the project is less likely to deliver the expected outcomes then the project's priority on the PCF should be downgraded.

6.2 Expanding access to VLSCI

For VLSCI to demonstrate that it is able to support the Commonwealth's research and innovation priorities it needs to allow life sciences research groups from all jurisdictions to have the same ability to access the PCF as Victorian research groups currently have. Doing so could deliver a number of benefits, including:

- opening the door to potential financial support from national research and innovation infrastructure programs
- a much broader pool of researchers from which to identify one or more flagship projects
- increasing the opportunity for collaboration between researchers from Victoria and other jurisdictions
- adding strength to the argument that Victoria is 'the place to be' for cutting edge life sciences research
- attracting more skilled people to come to Victoria to study and do research
- increasing the attractiveness of Victoria as a place to do business

Access to the PCF should continue to be based on the merit of the research proposal submitted to the RAS. Given the strong capabilities of Victorian researchers ACIL Allen expects that they would continue to enjoy an excellent level of access to the PCF.

If the University of Melbourne decides to continue to support the VLSCI with cash and in-kind contributions it would be appropriate to ensure that that contribution was recognised through some mechanism which allocated an agreed proportion of the available time on the PCF to the university.[40]

It is not clear how well the current operations of the LSCC could be extended across the whole country. The heavy emphasis on establishing close person to person relationships based on regular face to face meetings between the LSCC staff based in the three hubs making up the LSCC may be hard to apply across the whole of Australia.

The support offered by LSCC to life science researchers in Victoria has been instrumental in boosting the skills and capability of the sector. However, as the level of bioinformatics skills in the Victorian life sciences community grows the need for LSCC to play that role may decline.

One possible approach may be to match the level of subscriptions to the level of effort allocated to supporting 'new entrants' in the field of bioinformatics. For example, if subscriptions are to meet about half the staff costs at LSCC then those staff can support subscribers half the time and 'new entrants' for the other half of the time.

Over time, as skills and experience with using supercomputers grow we would expect that the need for 'new entrant' type support might decline and more resources could be devoted to meeting the needs of subscribers (and more subscription payments sought). One way of determining the appropriate level of resources that LSCC should commit to supporting subscribers would be to track the nature and level of demands for support that LSCC staff receive over time.

6.2.1 Expanding access – potential implementation measures

To implement expanded access to the PCF the VLSCI needs to modify the conditions governing who can submit an application for an allocation of time on the PCF. As noted above, a predetermined allocation of time could be provided to groups which provide ongoing funding to the VLSCI (such as the University of Melbourne).

LSCC should closely monitor the level of requests it gets for assistance in using the PCF. It should use that data to adjust the level of subscriptions it seeks to obtain. Note that this would require LSCC to categorise requests into those researchers who have some expertise and simply wish to collaborate with LSCC, and those that are 'new entrants'.

6.2.2 Improving governance arrangements

The present management arrangements could not be considered to represent a good governance framework. As illustrated in Section 2, there are a large number of committees with complex interrelationships (see Figure 3). This is a structure well suited to wide consultation among disparate stakeholders, and for management and coordination purposes. However, it is not well suited to governance. The multiplicity of bodies with roles that can cut across each other is likely to inhibit exercise of some key functions of governance, such as: strategy, oversight of risk and stewardship of the longer term future of the body.

[40] Such an approach is adopted for the NCI supercomputer at the ANU, with the groups getting an allocation of time that is broadly proportional to their financial contribution.

Oversight of risk in a well governed organisation includes not only monitoring whether the organisation has an effective risk management plan, but also conducting environmental scans for emerging risks and developing a board level plan for responses in the event that a catastrophic risk eventuates or in the event that the CEO is involved in some way in precipitating the risk. At present, the risk role appears to be spread across the Steering Committee and University Reference Group, with some specific aspects falling within other committees as well.

The present structure lacks clear lines of accountability and responsibility, especially accountability for performance. The potential for important governance issues, such as strategic planning to be neglected is reflected also in the lack of clear mechanisms for high level priority setting for the long term.

In the event that VLSCI is to continue to operate in the longer term, then a better governance structure will be needed to ensure it can be accountable for its performance, manage its risks and operate strategically. However, if the VLSCI's life is limited to the useful operational life of its capital equipment, the investment of time and effort required to reform its governance structures may not be justified.

In the event that the Victorian government decides that an ongoing role for VLSCI is desirable, then more effective governance structures are required. The question then would be what form of governance is best. Part of the answer to that question will be determined by the nature of the arrangements put in place.

It may be possible to invest the present Steering Committee with the roles and responsibilities of a board, restructure it to include independent directors, and select its membership based on skills rather than representation of interests. Other committees would then become only advisory, with the decision making powers vested in the management of VLSCI and the responsibility for holding management to account for the exercise of those powers and the performance of VLSCI resting with the Steering Committee/Board. This would be a quick and straightforward way to give the VLSCI a governance structure rather than its present management and consultation structure, and would represent a minimal change from the status quo.

However, such changes may be resisted by some current Steering Committee members or by some of the VLSCI stakeholders. In that event, a more fundamental restructuring would need to be considered. Options might include: moving to a corporate form (possibly a not for profit); inclusion of the VLSCI inside the governance arrangements of one of the present stakeholders (rather than spread amongst many as at present); or conversion of the VLSCI to a Victorian Government-owned statutory entity.

6.3 Future evaluations of VLSCI

As discussed in Section 1.4.2, larger projects allocated more than 5,000 service units are required to report to VLSCI. These stakeholders are asked to respond to an annual questionnaire administered by VLSCI. The topics covered by the questionnaires include:

- progress to date with their project
- publications and presentations resulting from the VLSCI project
- benefits to research provided by VLSCI
- facility use and options (current and future)
- grant monies awarded as a result of VLSCI
- additional employment opportunities as a result of VLSCI
- various administrative process, including ratings of:

- the Resource Allocation System
- e-mail help
- web content
- training and education
- communication

The questions used in the 2011 and 2012 surveys that were analysed for this report are listed in Table A1 in Appendix A.

6.3.1 Assessment of current data and questionnaire

Data collected from large projects has enabled an assessment of VLSCI in key research output areas. In particular the existing data provided:

- details of publications and presentations generated by research projects that used VLSCI computing resources. Most researchers acknowledge the role of VLSCI in their publications and presentations and thus promote VLSCI as a key enabler for life sciences research in Victoria to that national and global research community.
- details of grants awarded as a result of researchers being able to access VLSCI resources and an indication of the role that VLSCI played in attracting additional research funds to Victoria.
- information on additional employment created as a result of VLSCI being available to support research projects
- information on VLSCI's contribution to the Victorian life sciences skills pool.

We identified a number of potential problems in the 2011 and 2012 questionnaires which, if addressed, would increase the confidence in the survey results and enable VLSCI to more easily report on its contribution to life sciences in Victoria. These problems are discussed below.

Survey group

VLSCI needs to seek to better capture and track its interactions with its users. This includes persons using the PCF through the LSCC, participants in outreach activities and recipients of scholarships and other support provided by VLSCI.

Risk of double counting

The questionnaires do not specify a reference year for questions regarding the number of presentations/publications, grants and additional employment that have resulted from VLSCI. This omission resulted in several instances of double counting of key outputs.

Similarly, respondents are not told to only report on 'completed' outcomes such as published pieces; instead more instances of double counting occurred as outcomes 'in progress' were sometimes counted as 'completed', but then also reported in the next year. This was particularly the case for publications. For example, in 2012 about two dozen of the publications reported as completed in that year had already been reported as completed in 2011. The issue is a relatively minor one, but nonetheless it is worth addressing through improved wording of the questionnaire and better differentiation of outcomes that are 'completed' versus 'in progress'.

We stress that we are confident that ACIL Allen's analysis presented above takes into account any double counting across all outputs.

Role of VLSCI not scrutinised or acknowledged

The questionnaires request information on particular outputs or outcomes that have resulted from the researchers' involvement with VLSCI but no provision is made to measure the extent to which VLSCI influenced the ability to achieve that output or outcome. This issue can be addressed by including extent-scale questions.

Burden of data assessment

Some questions are not presented in a way that allows for easy assessment by VLSCI administrators. For example, questions requesting details of publications or presentations, grants and benefits have only one answer 'cell' which means bulk data is downloaded leading to a time consuming assessment of key outputs. For example, respondents were provided with one text entry box in which to list all the publications and presentations resulting from the project. The format was at the discretion of the respondent. As a result, in the spread sheet containing the responses to the questionnaire there were often large blocks of unformatted text in a single MS Excel cell. This considerably complicated the analysis of the data.

This issue could be addressed through improved questionnaire design for example, allowing for greater breakdown of key outputs into sub-items.

Additional data required

There were no questions regarding collaboration and commercialisation, both of which are important indicators of the longer term success of VLSCI. This weakness can be overcome by questions on these key outputs.

There is also scope to better capture improvements in clinical procedures that result from VLSCI supported research.

While ACIL Allen recognises that it will take some time for the results to flow through to market, there is value in collecting data on outputs such as patents and collaborative agreements as early indicators of potential future commercialisation. We note that collecting this information from early in the life of a research project also helps to establish a baseline of 'before VLSCI' activity against which change can be measured.

Only larger users are included

Responses to the questionnaires are only required from larger users (i.e. those with an allocation of more than 5,000 service units). This means that any results achieved by smaller users are not captured. This issue could be addressed by sending questionnaires to all VLSCI users regardless of their usage and using 'filtering' questions to allow for more detailed information to be sought from projects that warrant the additional attention.

6.3.2 Future development

Based on its experience in questionnaire design ACIL Allen suggests a number of changes to the existing VLSCI user questionnaire. The proposed changes are designed to address the key issues identified in Section 6.3.1. The suggested amendments to the questionnaire can be found in Appendix B in the following format:

- suggested questions for future evaluations, including type of question and answer options
- alignment of the new question(s) with the 2012 questionnaire
- identifying the rationale behind the suggested change.

Appendix A Past VLSCI questionnaires

The questions asked of those projects required to report in 2011 and 2012 are listed in Table A1. As shown in the table, the major difference across the questionnaires is that respondents were not asked to report on facility use and options in 2011. There are also minor changes to the wording of the administrative focussed in questions in 2012.

TABLE A1 **RELEVANT RESPONDENT QUESTIONNAIRES, 2011 AND 2012**

Topic	Questions asked in 2011	Questions asked in 2012
Progress	Please summarise the project's progress to date. Where possible, refer to the objectives outlined in your RAS application. [Please limit to 750 words.]	Please summarise the project's progress to date. Where possible, refer to the objectives outlined in your RAS application. [Please limit to 750 words.]
Publications and presentations	Please list all publications, conference and workshop presentations which have resulted from this project.	Please list all publications, conference and workshop presentations which have resulted from this project.
Benefit of VLSCI	Please describe the benefit to your research provided by VLSCI people and systems.	Please describe the benefit to your research provided by VLSCI people and systems.
2012 Facility use and options	Not asked in 2011	What are your current HPC options at your institution, elsewhere in Victoria, Australia and overseas? Name each facility and indicate what percentage of your total HPC use in 2012 was allocated to each (with zero use = 0%).
Future facility use and options	Not asked in 2011	What are your future HPC annual use estimates for 2013, 2014 and 2015 (in VLSCI service units, if possible) and indicate what proportion of this work you hope will be carried out through VLSCI (assuming RAS grant success)?
Grant success	Has the existence of VLSCI contributed to grant monies coming to your Victorian institution? If so, please document and quantify.	Has the existence of VLSCI contributed to grant monies coming to your Victorian institution? If so, please document and quantify.
Benefit to staffing	Has the existence of VLSCI's resources contributed to additional employment opportunities within your group and/or your collaborators – either directly or indirectly?	Has the existence of VLSCI's resources contributed to additional employment opportunities within your group and/or your collaborators – either directly or indirectly?
Resource allocation process	How would you describe the resource allocation process? *(Very straight forward; Straight forward; Appropriate level of effort; Difficult; Very difficult; N/A)*	How would you describe the resource allocation process? *(Very straight forward; Straight forward; Appropriate level of effort; Difficult; Very difficult; N/A)*
E-mail help	What is your project members' overall rating of the quality of the e-mail help service? *(Very good; Good; Adequate; Poor; Very poor; N/A)*	How would you and your project members rate the overall quality of the e-mail help service? *(Very good; Good; Adequate; Poor; Very poor; N/A)*
Web content	What is your project members' overall rating of VLSCI's web site as a source of technical help? *(Very good; Good; Adequate; Poor; Very poor; N/A)*	How would you and your project members rate the overall quality of the VLSCI's web site as a source of technical help? *(Very good; Good; Adequate; Poor; Very poor; N/A)*
Training and education	What is your project members' overall rating of VLSCI's training and education programme? *(Very good; Good; Adequate; Poor; Very poor; N/A)*	How would you and your project members rate the overall quality of VLSCI's training and education programme? *(Very good; Good; Adequate; Poor; Very poor; N/A)*
Communication	What is your project members' overall rating of VLSCI's communication channels? *(Very good; Good; Adequate; Poor; Very poor; N/A)*	How would you and your project members rate the overall quality of VLSCI's other communication channels such as twitter and e-news? *(Very good; Good; Adequate; Poor; Very poor; N/A)*
Comments	Please provide any additional feedback.	Please provide any additional feedback.

SOURCE: VLSCI

Appendix B Suggestions regarding the design of future questionnaires

ACIL Allen believes there is scope to make improvements to the questionnaire for collecting information about projects using VLSCI. The questionnaire below provides some suggestions for possible changes. We also believe there is good scope to make use of a more interactive on-line questionnaire format that uses the responses to particular questions to determine what subsequent questions are posed. Such an approach not only can be used to better target the kind of information sought, but also help to reduce respondent burden.

The suggested changes should not be seen as definitive. The precise wording and structure of a future questionnaire would need to be developed by VLSCI and take into account any decisions that might be taken as a result of this review.

TABLE B1 **SUGGESTED QUESTIONS TO ASSIST FUTURE EVALUATIONS OF VLSCI**

Topic	Suggested questions for future evaluations (in 20XX)	Equivalent/similar question in 2012	Rationale
Introduction	What was your involvement with VLSCI? 1. *A tick any box response. (respondents should be asked to select from 'VLSCC', 'LSCC', Outreach activities (such as seminar or workshop), grant recipient)*	Not previously asked	To broaden the range of stakeholders from whom information is sought and categorise the nature of questions asked.
Prior history with VLSCI	Have you had any prior involvement with VLSCI 2. *(Provide a list of options)*	Not previously asked	To try to build a history of stakeholders' involvement, i.e. have people moved from LSCC to RAS, have they been a recipient of a scholarship or other student support, etc.
Facility use	What was the total HPC service unit requirement for this project in 20XX? *Note: total includes VLSCI and non-VLSCI resources.* *(Number)* How many VLSCI service units did this project use in 20XX? *(Number)* Was this project active for the whole of 2012? *Note: if a project commenced part way through 2012, please consider the time after it commenced to the end of 2012 as "the whole of 2012".* *(Yes/No)* Do you expect to continue this area of research next year? *(Yes/No)* [Note: A 'Yes' answer could trigger a follow up question about whether the project intends to apply for additional computational time with VLSCI in subsequent years.]	What are your current HPC options at your institution, elsewhere in Victoria, Australia and overseas? Name each facility and indicate what percentage of your total HPC use in 2012 was allocated to each (with zero use = 0%). What are your future HPC annual use estimates for 2013, 2014 and 2015 (in VLSCI service units, if possible) and indicate what proportion of this work you hope will be carried out through VLSCI (assuming RAS grant success)?	Questionnaires should ideally be sent to all VLSCI users regardless of their usage. This will ensure that all benefits are captured. These questions will act as a filter for larger and smaller users of VLSCI, as well as determine how much allocation for each project is being used. Information about future plans for the research project not only give an indication of the perceived 'success' of the research stream to date and its 'prospectivity' but also provide an early indication of likely demand for computing resources.
Progress	Briefly describe the progress made on this project using VLSCI in 20XX. (300 word limit)	Please summarise the project's progress to date. Where possible, refer to the objectives outlined in your RAS application. [Please limit to 750 words.]	Some respondents had a tendency to describe in detail their project rather than discuss progress. Respondents should be encouraged to focus on progress in 20XX, including if the project remains active. This and lower limits on the length of responses will make analysis of responses easier. It could also reduce respondent burden.
Publications and presentations	How many publications and/or presentations resulted from this project in 20XX? Only include those articles and/or presentations that were finalised (i.e. articles that were printed in 20XX, presentations that were made in 20XX, etc). a) Publications in journals, etc *(Number)* b) Presentations overseas *(Number)* c) Presentations in Australia *(Number)* [Respondents could also be asked to list publication titles and journal names. While this would add to respondent burden it would help avoid double counting and assist with evaluations of the impact of publication (based on JIF)]	Please list all publications, conference and workshop presentations which have resulted from this project.	Respondents will only be allowed to record 'new' and 'completed' publications and presentations in that year. In a separate question, they will be asked to record 'works in progress'. This will attempt ensure that only previously unrecorded publications and presentations are reported as a means of avoiding double counting (backward and forward). While the quantity of the publications and presentations is indicative of the extent to which VLSCI projects are being

	How many publications and/or presentations are 'in progress', e.g. have been submitted or approved but not yet printed, currently being written, invited for delivery in the future? a) Publications in journals, etc *(Number)* b) Presentations overseas *(Number)* c) Presentations in Australia *(Number)*		reported, it does not indicate the extent to which VLSCI was referred to in the publication/presentation. E.g. if VLSCI is not referred to in a publication, then the possible exposure to VLSCI does not necessarily exist. Our question attempts to measure how much VLSCI and its capabilities is being introduced to readers.
	To what extent has the use of VLSCI in this project been acknowledged in these publications and presentations? *(I acknowledge VLSCI in all publications and presentations; I acknowledge VLSCI in most publications and presentations; I acknowledge VLSCI in some publications and presentations; I don't acknowledge VLSCI in my publications and presentations)*		
Grants	Please record the number of grants applied for and awarded in 20XX. a) Applied for in Australia b) Awarded in Australia c) Applied for overseas d) Awarded overseas	Has the existence of VLSCI contributed to grant monies coming to your Victorian institution? If so, please document and quantify.	These questions will allow for easier analysis of the grants awarded and applied for and will provide a better indication of the role of VLSCI in winning grants.
	For each grant awarded in 20XX, please specify a) the agency awarding the grant b) grant number (if applicable) c) the value ($A) of the grant d) the duration of the grant *(Comment box)*		
	Considering all grants awarded in 20XX, how important was your ability to access VLSCI to the awarding of these grants? *(Extremely important, Important, Moderately important, Somewhat important, Not very important)*		
Benefit to staffing	Please identify additional staff did you take on in 20XX to work directly or indirectly with VLSCI resources. a) We did not take on any additional staff in 20XX. b) Undergraduate *(Number)* c) Post graduate *(Number)* d) PhD *(Number)* e) Post doctorate *(Number)* f) Other *(Number)*	Has the existence of VLSCI's resources contributed to additional employment opportunities within your group and/or your collaborators – either directly or indirectly?	This question allows for the itemisation of additional employees and restricts it to new employees in 20XX as a means of avoiding double counting.

Collaboration	Please identify any collaborative activities stemming from this VLSCI project in 20XX. a) We did not collaborate in 20XX b) Collaborations with other Victorian researchers c) Collaborations with other Australian researchers d) Collaborations with researcher overseas e) Collaborations with industry *(Yes/No)*	Not previously included	ACIL Allen believes that enhanced collaboration is a potential benefit of VLSCI. Collaboration (with the private sector) can also provide an early indication of potential commercial outcomes. These questions attempt to measure the extent and nature of collaborative activities.
	[If yes], please briefly discuss the collaboration(s), including who the collaboration was with and the purpose. *(Comment box, 300 words)*		
Commercialisation	Please outline any significant steps towards commercialisation that this project may have undertaken in 20XX (e.g. applied for a patent).	Not previously asked	ACIL Allen identified commercialisation as a benefit of VLSCI. These questions attempt to measure the extent of collaborative activities.
Clinical application	Please tell us whether this project has led to any changes in clinical procedures in 20XX.	Not previously asked	To capture changes in clinical procedures resulting from VLSCI supported research
Outreach	Persons checking the outreach box should be asked specific outreach related questions.	Not previously asked	To better track what outreach activities stakeholders are participating in and what their views are of these.
Benefits	How important was access to VLSCI in this project being able to get off the ground? *(Extremely important, Important, Moderately important, Somewhat important, Not very important)*	Please describe the benefit to your research provided by VLSCI people and systems.	Analysis of 2012 data found common themes discussed by respondents and these have been converted into questions to ascertain the usefulness and effectiveness of VLSCI. Separate questions will allow for easier analysis and reporting.
	How important was access to VLSCI for carrying out this project? *(Extremely important, Important, Moderately important, Somewhat important, Not very important)*		
	To what extent could this project have been carried out on other High Performance Computers (other than VLSCI)? *(Not at all, to some extent, entirely)*		
	Briefly discuss why VLSCI was used for this project as opposed to other High Performance Computers. *(Comment box, 300 word limit)* [Note: This question should be tailored to match the response to the preceding question.]		
	Did your actual VLSCI resource allocation in 20XX meet the needs of your project? *(Yes, No)*		

Administration	Please rate each of the following in terms of the overall quality of the function/element provided in 20XX. *(Very good; Good; Adequate; Poor; Very poor; N/A)* a) VLSCI's e-mail help service b) VLSCI website as a source of technical help c) VLSCI's education and training program d) VLSCI's communication channels such as Twitter and e-news e) VLSCI support staff	How would you and your project members rate the overall quality of the e-mail help service? *(Very good; Good; Adequate; Poor; Very poor; N/A)* How would you and your project members rate the overall quality of the VLSCI's web site as a source of technical help? *(Very good; Good; Adequate; Poor; Very poor; N/A)* How would you and your project members rate the overall quality of VLSCI's training and education programme? *(Very good; Good; Adequate; Poor; Very poor; N/A)* How would you and your project members rate the overall quality of VLSCI's other communication channels such as twitter and e-news? *(Very good; Good; Adequate; Poor; Very poor; N/A)*	This question condenses four previous questions. More functions/elements can be added as necessary.
Comments	Please provide any other comments on your experience (good or bad) with VLSCI in 20XX.	Please provide any additional feedback.	
Suggestions	Are there any areas where VLSCI could or should do things differently? *3. (Comment box, 300 word limit)*	Not previously asked	

Appendix C Case studies

C.1 Introduction

In section 4 of the report we have discussed some of the benefits that access to the VLSCI has already brought to Victoria and to Victorian researchers. However, there are also benefits that are only likely to be realised in the longer term. While some of these benefits are likely to be substantial, their timing is much more uncertain, although the translation from science discovery to drug or treatment delivery is normally measured in decades.

This section discusses four case studies which we believe demonstrate the potential positive impact that research supported by access to VLSCI infrastructure and supporting expertise may bring.

The case studies demonstrate how access to leading edge supercomputing facilities can assist researchers to address significant health and economic challenges facing the State of Victoria, Australia, and indeed the rest of the world. They were selected following consultation with a broad range of stakeholders including, researchers, government officials and leaders within VLSCI.

C.2 Case study 1: Advancing the treatment of ovarian cancer

C.2.1 The research problem

Ovarian cancer is the eighth most common cancer and the sixth most common cause of cancer death affecting women in Australia. In 2009, over 1,300 new cases of ovarian cancer were diagnosed in Australia. In the same year 848 deaths were recorded as being caused by this form of cancer.

In 2013 the Cancer Council of Australia published a report that suggested that women have a 1 in 75 risk of being diagnosed with ovarian cancer before the age of 85.

There are no proven screening tests for ovarian cancer. However, ultrasounds and blood tests are being investigated by medical researchers as potential screening tests for this cancer.

Also there is no proven method for preventing ovarian cancer. Oophorectomy (the removal of ovaries) in women with a strong family history of this disease is currently the preferred method of prevention. However, removal of the ovaries does not completely eliminate the risk of getting this form of cancer.

The treatment of ovarian cancer depends on the extent of the cancer within a patient.

C.2.2 The research and VLSCI

Working with clinicians, Professor David Bowtell and his research team at the Peter MacCallum Cancer Centre have demonstrated that one type of ovarian cancer, notoriously resistant to conventional ovarian cancer therapy, is responsive to treatment with a drug normally prescribed for renal cancer.

The research has the potential to allow the classification of cancer according to gene activity and identify where key “markers” related to specific biochemical pathways

cause cancer. Once the cancer has been effectively identified it allows for the appropriate treatment response.[41]

The Peter MacCallum team is also involved in The Cancer Genome Atlas Project, which is assembling a comprehensive catalogue of all the genetic mutations in human cancers. This large analytical exercise involves sequencing 500 samples of the most common cancers.

The VLSCI's supercomputing facilities and the expertise of the LSCC's bioinformatician supporting the work are viewed as essential to the successful outcome of this research. The LSCC bioinformatician plays a vital role taking gigabytes of sequencing data, correcting for errors, aligning it into the three-billion base pair DNA sequence of the human genome, and then comparing that with the published reference sequence to pick up variations or mutations. The LSCC bioinformatics experts provide a central point for assistance which can be embedded into all phases of the research process.

According to Professor Bowtell:

> Having such equipment and skills locally makes a huge difference. It means you have some control over processes which are critical to a whole lot of research programs—and do not become a hostage to the priorities of others. Also you become a magnet to draw good people to you. In Melbourne we can now say that we have all the pieces of the puzzle together and we are ready to go.

C.2.3 Impact of the research

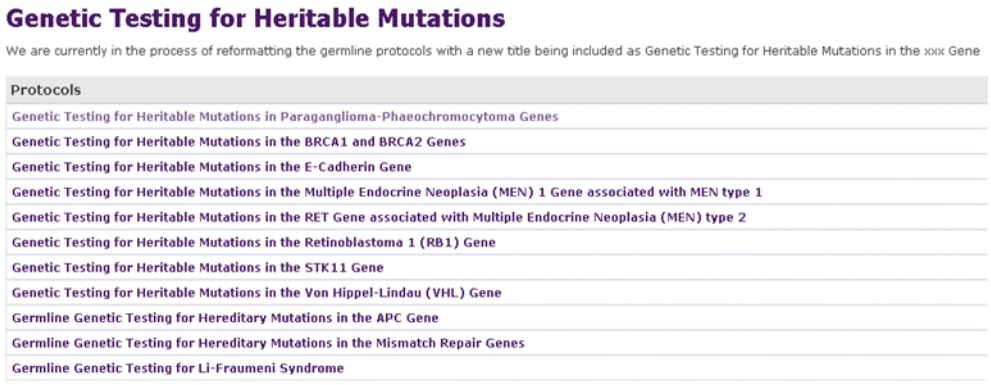
Consultation with a senior research leader at the Institute has identified the direct impact of Peter MacCallum's research on current medical practice. It has identified that research findings have been integrated into the NSW Cancer Institute's protocols/guidelines for genetic testing and referrals – these protocols and guidelines can be accessed through the eviQ Cancer Treatments Online portal (https://www.eviq.org.au/).[42]

Figure C1 provides a screen shot of the types of protocols provided on the eviQ Cancer Treatments Online portal, and the types of protocols that are being developed following the publication of VLSCI-supported research.

[41] 2011 Annual Report, VLSCI

[42] eviQ Cancer Treatments Online is a point of care clinical information resource that provides health professionals with current evidence based, peer reviewed, best practice cancer treatment protocols and information. eviQ allows rural, remote and metropolitan health professionals, patients, carers and their families access to the same standard evidence based information. eviQ can be accessed free 24 hours a day. eviQ was launched in October 2009. By February 2013 eviQ had over 25 000 registered users from around Australia and internationally.

FIGURE C1 **CASE STUDY 1 – EXAMPLE OF VLSCI SUPPORTED RESEARCH USED IN CLINICAL PRACTICE**



SOURCE: EVIQ2013, https://www.eviq.org.au/category/tabid/65/categoryid/440/default.aspx

The results of VLSCI-supported research have also been used to inform the referral practices for patients with Ovarian Cancer. There is also considerable potential for this kind of research to inform the other types of cancer, such as gastric and renal cancer.

While consultations for this project did not extend to the practitioners who use these protocols/guidelines, consultation with a senior research leader at the Institute did indicate that the protocols/guidelines are having a positive influence on the testing and referral of cancer patients. It is anticipated that this influence will grow as additional research is disseminated amongst practitioners across Australia and overseas, and further integrated into protocols/guidelines.

Potential value of research

Improved protocols for testing patients for cancer and referring them for treatment is expected to lead to improved patient outcomes. Improved patient outcomes will, over time, help to reduce the cost (or burden) of cancer on the Victorian economy.

The economic burden of uterine, ovarian and cervical cancer has been estimated for other jurisdictions seeking to understand the total life time costs of cancer to state economies.[43] In 2005, Access Economics estimated that the total life time cost of uterine, ovarian and cervical cancer to be $1.195 billion (or 0.04 per cent of Gross State Product).[44]

Using this estimate, ACIL Allen has calculated the equivalent cost of cancer for Victoria. When adjustments are made for differences between Victoria's and NSW's population (in 2013) and adjustments are made for CPI inflation between 2005 and 2013, ACIL Allen estimates that the potential total economic cost of uterine, ovarian and cervical cancer to the Victoria could be up to $1.15 billion in 2013.[45]

If we assume that through the research supported by VLSCI better detection techniques could be identified and implemented, and if these improvements in detection lead to a direct reduction in the total economic cost of uterine, ovarian and cervical cancer by 10 per cent per year, our high level estimates suggest that VLSCI supported research could deliver a total economic benefit of $150 million to the

[43] Total lifetime economic costs are defined as the costs of people diagnosed with cancer in 2005, plus any future costs associated with those people.

[44] Access Economics 2005, *Cost of Cancer in NSW*, Report to the Cancer Council of NSW.

[45] Based on ABS population figures and official government inflation data.

State of Victoria. Additional economic modelling and analysis would be necessary to ensure this benefit is accurately calculated for Victoria.

C.3 Case study 2: 'Worm genome unlocks disease clues'

C.3.1 The research problem

Roundworm infections affect more than one billion people around the world. The worms are (accidently) ingested from contaminated food and water and hatch inside the host's intestine causing malnutrition. This in turn leads to long term physical and cognitive problems especially in children.

The parasite (known as *Ascaris lumbricoides*) causes a disease called ascarisis, which kills around 135,000 people (mainly children) in developing regions of South East Asia, China, South America and Africa.

The World Health Organisation has estimated that up to 1 billion people could experience the burden of parasitic disease in developing tropical nations (WHO 2013). According to researchers,

> the cost of harbouring parasites in terms of human misery and economic loss is incalculable.[46]

C.3.2 The research and VLSCI

An international team of scientists, from the University of Melbourne, have sequenced the genome of the common roundworm, which infects pigs, called *Ascaris suum*. The team has developed a 273 million base genome sequence of the worm in the hope that it can lead to the development of treatments for both animals (especially sheep and cattle) and humans.[47]

The pig based parasite is a very close relative of the parasite that affects humans, and the researchers are hopeful that the sequencing of the *Ascaris suum* genome will result in the development of new, urgently required interventions for humans – including vaccines, drugs and diagnostic tests. It is hoped that sequencing will reveal important insights as to how immune systems respond to the presence of parasites that can be applied to other disease factors such as cancer and HIV/AIDS.

In an interview with ABC Radio, research leader, Dr Aaron Jex, was quoted as saying:

> Although developing a vaccine against these types of parasites is extremely difficult to do, the hope is the more you understand about that interaction between the parasite and the host at the immune level, the more likely it is that you could try to develop vaccines.
>
> At least with this information you are one step closer.
>
> With only one drug currently used to treat humans and three for animals it is critical that new treatments are developed. There haven't been huge advances in developing drugs for these things for quite some time. If the parasites become resistant to the existing drugs we don't have an alternative.
>
> By sequencing the genome we can probably develop new drugs.

A significant allocation of VLSCI resources in 2011 was "absolutely pivotal" to the success of the research and its publication in one of the world's premier journals (*Nature*). Access to the VLSCI facility aided the group of over 12 researchers (from

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[46] Northrop-Clewes, C. and C. Shaw 2000, *Parasites*, British Medical Bulletin, 56 (No 1) 193-208.

[47] ABC 2011, 'ABC Science News Radio: Worm Genome Unlocks Disease Clues', http://www.abc.net.au/science/articles/2011/10/27/3349715.htm

around the world) to collaborate with some of the world's largest genome-sequencing facilities. These include:

- BGI-Shenzhen in China
- the Natural History Museum in Britain
- George and Washington University in the USA.

C.3.3 Impact of the research

The pursuit of this research has a number of potential benefits to health of industries and communities. For example, Meat and Livestock Australia have estimated that the national economic impact of internal parasites to the sheep industry was over $38 million of lost income and over $83 million worth of increased expenses to producers.[48] The costs of parasites are the highest annual animal health costs faced by Australia's sheep industry.[49] While the same modelling has estimated that the economic cost of intestinal parasites to beef cattle was over $38 million of lost income to the industry. A significant proportion of these losses are likely to occur in Victoria.[50]

The ABS estimates that Victoria has over 32,000 farms, 14.4 million head of sheep and lambs, 2 million head of beef cattle, 500,000 pigs.[51] Clearly there are many Victorian farmers who could potentially benefit from the development of effective drug treatments against parasites.

C.4 Case study 3: 'First 3D image of the common cold virus'

C.4.1 The research problem

In an increasingly interconnected world where information, goods, services and people flow between geographic regions, with unprecedented speed and volume, the spread of human viruses can have significant social and economic impacts. Unlocking the mechanisms of these viruses is of growing importance for both 'human wellbeing and our global connectivity'.[52]

The Human Rhinovirus (HRV) is the most frequent cause of common colds in people. HRV infection is a major cause of hospitalisation for patients with underlying

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[48] *Assessing the Economic Cost of Endemic Disease on the Profitability of Australian Beef Cattle and Sheep Producers*, MLA (Meat Livestock Australia) 2006, http://www.mla.com.au/CustomControls/PaymentGateway/ViewFile.aspx?mFDUp1AYI9VUf+h/ZH4CYhopVLs5O3WvlD8Tvjx4WwqIhJCS8/UdRwc9AKswn/HN3EYMKKAfsht7d1Tnt3BqiA==

[49] *The Cost of Round Worms*, Wormboss 2013, http://www.wormboss.com.au/worms/roundworms/the-cost-of-roundworms.php

[50] The report considered that worms were only a risk in southern herds, with those at high risk within this region in areas with average annual rainfall of greater than 600mm. 'Bureau of Meteorology data were used to determine the boundaries and although these were as precise as possible, some provision had to be made as to the exact allocation of these areas. The statistical divisions not included within the analysis are North Western, Far West, 30 per cent of Central West, 50 per cent of Murrumbidgee and 70 per cent of Murray in New South Wales; Wimmera, Mallee, Loddon and Goulbourn in Victoria; Yorke and Lower North, Murray Lands, South East and Eyre in South Australia; and Upper Great Southern and 40 per cent of Midlands in Western Australia' (MLA 2006).

[51] *Agricultural Commodities, 2011-12*, ABS (Australian Bureau of Statistics) 2011-12 http://www.abs.gov.au/websitedbs/c311215.nsf/web/Agriculture+-+Summary+Map+-+Agricultural+Commodities

[52] Wagner, J, *Nothing to sneeze at: IBM Supercomputer takes on the common cold*, Building a Smarter Planet Blog, 17 July 2012.

respiratory conditions, such as asthma, chronic obstructive pulmonary disease and cystic fibrosis, where HRV can aggravate the underlying existing disease.[53]

Estimates suggest that HRV is linked to about 70 per cent of all asthma exacerbations and more than 50 per cent of the hospitalised cases. HRV can be a serious problem for infants and the frail elderly. For example, in the USA, 75 per cent of common colds in children under five years old are medically attended and HRV has been linked with roughly one third of children with middle ear infections.[54]

HRV is the second most frequent infection associated with pneumonia and bronchiolitis in infants. There is also growing evidence for HRV as the causative agent for severe lower respiratory tract illness in older adults.[55]

There is currently no effective treatment of HRV in Australia or overseas.

C.4.2 The research and VLSCI

In collaboration with researchers at the IBM Collaboratory, scientists from St Vincent's Institute of Medical Research and the University of Melbourne have used a VLSCI's supercomputer to model the common cold at the molecular level. With the assistance of IBM's supercomputing technology and LSCC's expertise these researchers are working to build a 'fully atomistic, three-dimensional simulation of HRV. The simulation includes the more than three million atoms of the HRV, as well as the packet of genetic information necessary for the virus to replicate and spread.[56]

The inclusion of the genome in simulations is especially critical to the research, as it affects the HRV interaction with potential drugs. These simulations allow researchers to gain a more precise picture of how drugs attack HRV at the molecular level.

The collaboration used a significant allocation of time on the IBM Blue Gene /Q supercomputer to undertake the research. Access to the IBM Blue Gene /Q supercomputer is seen as vital in providing the processing power necessary to simulate viruses at the molecular level.[57]

C.4.3 Impact of the research

The first 3D image of HRV, responsible for 40 per cent of all colds, has been used by the research team to better understand how a new drug, developed by a Victorian company, Biota Pharmaceuticals, works.

The drug is aimed at stopping the HRV from spreading. It is targeted as a treatment for people with chronic lung diseases like asthma, chronic pulmonary disease and cystic fibrosis, for whom a common cold can be fatal.

The significance of this research extends well beyond HRV. St Vincent's Institute of Medical Research Deputy Director, Professor Michael Parker, who led the research, explained that:

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[53] *HRV Phase IIb Study Achieves Primary Endpoint*, Biota, Press Release, 2012, http://www.biotapharma.com/uploaded/154/1021819_20hrvphaseiibstudyachieve.pdf

[54] *Human Rhinoviruses: Coming in from the Cold*, NCBI (National Centre for Biotechnology Information) 2012, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2684665/

[55] *HRV Phase IIb Study Achieves Primary Endpoint*, Biota 2012, Press Release, http://www.biotapharma.com/uploaded/154/1021819_20hrvphaseiibstudyachieve.pdf

[56] Wagner, J., *Nothing to sneeze at: IBM Supercomputer takes on the common cold*, Building a Smarter Planet Blog, 17 July 2012.

[57] 2010 Annual Report, VLSCI

> …. understanding how the Rhinovirus responded to the drug had implications for a wider range of illnesses. An increase in understanding how existing drugs work with one virus will pave the way for the development of new anti-viral medications for related viruses [such as polio and meningitis] and hopefully save lives around the world [58]

IBM has estimated that there are approximately 45 million occurrences of the common cold annually in Australia. These cost employers 1.5 million workdays, or approximately $600 million in lost productivity per year.[59] These estimates also suggest that Australian's spend more than $250 million per year cold and cough remedies that are not proven to be effective treatments of the virus. Ongoing research, which contributes to our understanding of the common cold, assists in the development of drugs and preventative methods that would help to minimise the cost to the economy and the community from this virus. For example, even just a 10 per cent reduction in the number of lost work days would lead to a $60 million benefit to the economy.

The development of a successful treatment of the common cold could also be very profitable for the firm that developed it. For example, research into the structure of the neuraminidase protein during the 1980s, is credited for helping to develop anti-influenza drugs that now have an estimated annual worldwide sales value of more than $3 billion.[60] According to CSIRO's website:

> The determination of the three dimensional structure of the neuraminidase protein by Peter Colman and his colleagues at CSIRO in the 1980s, and its use in the development of the anti-influenza drug zanamavir (Relenza®) is a landmark medical discovery. Relenza® and the closely related oseltamivir (Tamiflu™) subsequently developed by the US-based company Gilead Sciences in collaboration with Roche, were both designed on the CSIRO neuraminidase structure and both drugs work against all strains of influenza virus including bird flu and swine flu.
>
> These drugs, called neuraminidase inhibitors, represent a new class of anti-viral agent and have world-wide annual sales in excess of $3 billion. They target the enzyme, neuraminidase, which is found on the surface of all strains of the influenza virus. Neuraminidase plays an important role in releasing new virus particles from the surface of infected cells, enabling the virus to spread.[61]

C.5 Case study 4: Developing a bionic eye

C.5.1 The research problem

It is estimated that there are about 300,000 people who are blind or vision impaired living in Australia. The impact of vision impairment depends on the type, extent and timing of vision loss. Some people gradually lose vision over a number of years; others are blind from birth. Some may have no vision at all. However, most people who are legally blind have some vision and may be light-sensitive, have low or limited vision, or have limited peripheral vision. With some vision impairments, sight

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[58] *First Image of 3D Common Cold Virus could lead to New Drug Treatments*, Herald Sun, 16 July 2012.

[59] *IBM takes a Really Close Look at the Common Cold*, IBM 2012, http://asmarterplanet.com/files/2012/07/IBM-Common-Cold-Infog_1.pdf

[60] The company that owns and sells Relenza, GlaxoSmithKline, currently has a market capitalisation of $123.62 billion, approximately 99,500 staff worldwide, and revenue of $46.42 billion (October 2013) (http://finance.yahoo.com/q/co?s=GSK+Competitors).

[61] http://www.csiropedia.csiro.au/pages/viewpage.action?pageId=426541

fluctuates and people may experience some days when vision or light tolerance is much better than others.[62]

The total costs of vision impairment (in Australia) are significant. Work commissioned by Eye Research Australia (in 2004) showed that the total real financial cost (direct and indirect) of vision disorders was $5.0 billion (equivalent to 0.6 per cent of GDP at that time). The net cost of suffering and premature death due to vision loss, over and above its financial costs, was estimated to be a further $4.8 billion in 2004.

C.5.2 The research and VLSCI

The VLSCI is playing a key role in bionic eye research. VLSCI is giving researchers from Bionic Vision Australia (BVA) access to facilities which allow them to study how the retina (a very thin tissue that acts like the film in a camera to convert what we see into messages that the brain can interpret) can be simulated. The retina is located at the back of the eye and translates the light that falls on it into nerve signals that travel via the optic nerve to the brain. Damage to the retina causes vision loss, such as in the disease retinitis pigmentosa (RP).[63]

The bionic eye uses an electronic implant placed behind the retina, which is connected to a video camera built into a pair of sunglasses. The camera converts images into electrical impulses which activate the remaining cells in a diseased retina. The cells then send visual information along the optic nerve to the brain, where the image is interpreted. In this way the bionic eye mimics the function of the retina and helps to restore some basic sight.

Researchers from BVA have been working with the supercomputing facility since 2011, on a range of projects contributing to the promise of bionic vision. BVA is developing prosthetic retinal devices to restore a sense of vision to people with retinitis pigmentosa and age-related macular degeneration.[64]

For example, since 2011 Professor Anthony Burkitt from the University of Melbourne, has led an investigation of the different ways to stimulate the eye with to the aim of developing the bionic eye. Staff from the VLSCI's PCF and the IBM Collaboratory in Melbourne have worked closely with Professor Burkitt's team. They have investigated the retina's neural structure in a way that would not be possible on a conventional computer system. Postdoctoral researchers, postgraduate and undergraduate students associated with the project have benefitted from formal and hands-on training.

Indirectly, the access to HPC facilities and the expertise of VLSCI staff has facilitated national and international interactions with other research groups who do not have the benefit of such powerful HPC facilities or expertise to solve their computationally-demanding problems. It has allowed these groups to undertake modelling of retinal neurons that delivers finer-grained picture of the neuronal structure within the retina than has previously been available.[65]

According to one of the researchers, Dr Tahayori from the University of Melbourne:

> Doing this kind of work requires a huge number of simulations, and huge amount of computer power to do them.

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[62] Australian Disability Clearinghouse on Education and Training 2013, *Vision Impairment and Blindness*, http://www.adcet.edu.au/Specific_Impairments/Vision_Impairment_and_Blindness.chpx

[63] Bionic Vision Australia 2012, *Bionic eye researchers working with the Victorian Life Sciences Computation Initiative*, http://bionicvision.org.au/news/story/bionic_eye_researchers_working_with_victorian_life_sciences_computation_initiative

[64] Centre for Eye Research Australia 2013, *Bionic Eye*, http://www.cera.org.au/our-research/key-projects/bionic-eye

[65] 2011 Annual Report, VLSCI.

> Without a doubt this project wouldn't have been possible without the VLSCI. We could run multiple simulations in parallel, something that is not possible without a computing facility like VLSCI.[66]

According to a PhD student with BVA based at the University of Melbourne:

> Using VLSCI has been enormously beneficial because it enabled us to do a total of 75,000 hours' worth of simulations, a feat that would have impossible in the time frame to do on a normal computer. At times we were running 100 or 150 simulations at the same time.

C.5.3 Impact of the research

In August 2013, the researchers working on the bionic eye reached a major milestone in becoming the first group to achieve a successful bionic eye implant. The recipient of the transplant, Ms Dianne Ashworth, has profound vision loss due to retinitis pigmentosa, and the transplant has allowed her to perceive 'shapes' and 'flashes of light' for the first time.

The consortium behind the research team, Bionic Vision Australia, said that while the implant is still an early prototype the results had given the team confidence. In an interview reported in *The Australian* newspaper on 30 August 2013, Bionic Vision Australia's Chairman, Professor David Penington was quoted as saying:

> Much still needs to be done in using the current implant to build images for Ms Ashworth. The next big step will be when we commence implants of the full devices.

Estimates by Invest Victoria place the potential value of the bionic eye at more than $70 million to the state's economy over the four year period 2010-2014. Invest Victoria has also estimated that the prototype of the bionic eye will generate more than 90 new jobs for the State's biotechnology industry.[67]

The development of the Cochlear implant for certain types of deafness shows the potential benefits of supporting the development of high quality technology medical prosthetics over many decades. In the 1970s and 1980s Cochlear received significant public funding to undertake and commercialise research into hearing implants and by 1983 had delivered the world's first 22 channel implant.[68]

Cochlear Ltd Australia has enterprises in the USA, Japan, Switzerland and Australia delivering implant systems to people in 50 countries. In October 2013, Cochlear Ltd reported to the Australian Stock Exchange a market capitalisation of approximately $3.31 billion, sales revenue of $715 million, an expected profit for 2013-2014 of more than $132 million, and directly employed approximately 2,700 workers across 25 countries.[69]

Today, the Cochlear implant stands as the world's most widely used cochlear implant systems, with more than 219,000 people worldwide having received cochlear implants since the 1980s.[70] Cochlear Ltd also stands as a significant

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66 *Bionic eye researchers working with the Victorian Life Sciences Computation Initiative*, Bionic Vision Australia 2012, http://bionicvision.org.au/news/story/bionic_eye_researchers_working_with_victorian_life_sciences_computation_initiative

67 *Victorian Vision for the Future Worth $70 million*, Invest Victoria Press Release, 2010 http://www.invest.vic.gov.au/200410Victorianvisionforthefutureworth70million

68 *Cochlear's History of Innovation*, Cochlear, 2013, http://www.cochlear.com/wps/wcm/connect/intl/about/company-information/history-of-innovation/cochlears-history-of-innovation

69 *Cochlear Annual Report to Shareholders*, cochlear, 2013, http://www.asx.com.au/asxpdf/20130913/pdf/42jbn3fb8gfy9z.pdf

70 2010, *Research*, NIDCD (National Institute on Deafness and other Communication Disorders)http://www.nidcd.nih.gov/Pages/default.aspx

example of the value that can be generated from public investment in bio medical research.