Submission
2016 National Research Infrastructure Roadmap
Capability Issues Paper

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Questions

Question 1: Are there other capability areas that should be considered?

Vibrational Spectroscopy and Spectroscopic Imaging Network (see attached sheets)

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Yes

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

When there is domain expertise in Australia but the size of the research community is not large enough to justify the expenditure nationally. This could include access to specialist equipment capabilities in synchrotron radiation and neutron sources where Australia has considerable expertise but it is not feasible to cover all of the cutting-edge experimental capabilities available in overseas facilities within the Australian Facilities

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes, if we are to drive innovation nationally, we must have access to cutting-edge science and technology and an ability to train a specialised workforce in these capabilities as appropriate.

Question 6: How can national research infrastructure assist in training and skills development?

Not only can the establishment of new infrastructure provide training and skills development if appropriately funded for research personnel; it can also provide on-line training through programs such as MyScope that was established by the AMMRF. It also produces people with the right skill set that will ultimately create new business opportunities in Australia thus allowing us to become more competitive in a global market and hopefully allow the retention of IP in the country compared to the current situation where IP has to be sold due to lack of internal infrastructure.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

The role of research institutions is twofold. Firstly, they must be better aligned with new and existing industrial partners to provide essential resources that help develop these organisations to be globally competitive. This can only be achieved through proper government-based industrial incentive schemes that are rewarded based on results. Secondly, research institutes can provide internal programs that make their people more employable. This includes internal training and context-based situational learning, such that the transition from research to industry is better facilitated.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

Access to research instrumentation should be based on three principles: (i) research excellence; (ii) enhancing the skill sets and research potential of early career researchers; (iii) supporting research and development to drive the innovation program of industry and government; and (iv) contribute to important social issues such as health, the environment and social wellbeing. This means that access to research infrastructure is based not only on best fit of the research group to the problem at hand, but also based on results, i.e. more access to those groups that produce results and grow the country's business opportunities and contribute to societal demands for a better environment and social setting.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

Defunding/decommissioning should be purely based on an accountability system. A clear set of guidelines has to be developed and systematically checked off based on the objectives stated in the proposal for the infrastructure. Failure to adhere, as assessed by qualified and independent project auditors, should result in defunding.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

The investment in high quality research infrastructure needs to consider both short and long-term potential for research, development and training that will drive innovation. Too much emphasis on short-term outcomes can be a recipe for mediocrity in the search for quick results. Real game-changing networks and infrastructure developments can take several years to reach a level of maturity that leads to the highest long-term impacts.

Question 11: When should capabilities be expected to address standard and accreditation requirements?

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

Health and Medical Sciences

Question 15: Are the identified emerging directions and research infrastructure capabilities for Health and Medical Sciences right? Are there any missing or additional needed?

Vibrational spectroscopy is producing an emerging array of a relatively inexpensive, reliable and versatile set of tools for early and rapid diagnosis of cancer, infectious diseases, cardiovascular disease, etc. It is also used extensively in new drug developments. Australian facilities and researchers are world leaders in many of these areas.

Question 16: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 17: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Health and Medical Sciences capability area?

Environment and Natural Resource Management

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?

Environmental monitoring, both remote monitoring and detailed investigations of the source and toxicity of pollutants using vibrational spectroscopy is another core capability of Australian researchers and facilities.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

Advanced vibrational spectroscopy and vibrational spectroscopy imaging of complex materials (hard, soft and biomaterials and tissues) is a major area of research strength in Australia. It also requires advanced and complex chemometric analysis that mine the information rich data sets obtained from such imaging. There is also emerging expertise in vibrational nanospectroscopic imaging with new technology capable of spatial resolution of 10 nm, which will underpin nanoscience in Australia. If we are to drive innovation in these areas investment in the latest advances in these rapidly emerging techniques is essential.

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

Understanding Cultures and Communities

Question 24: Are the identified emerging directions and research infrastructure capabilities for Understanding Cultures and Communities right? Are there any missing or additional needed?

Vibrational spectroscopy has played a key role in archaeology, palaeontology and cultural aspects in analysis of artworks and other artefacts for forgeries and restoration. Again this is an area of considerable expertise in Australia and networks are being developed to increase the use of vibrational spectroscopy in these areas in universities, museums and art galleries.

Question 25: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 26: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Understanding Cultures and Communities capability area?

National Security

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

The ability of vibrational spectroscopy to identify just about any material and the advent of high performance portable and hand-held instruments has already found many applications in forensic labs, hazmat labs, etc. in Australia. There is considerable potential for the expansion of these capabilities through this network to tackle a range of National Security issues to which they are applied already..

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

On-line process control, remote monitoring and efficiency optimisation using vibrational spectroscopic probes and advanced chemometrics is considered to be state-of-the art in many industries such as primary production and processing of food, mining, mineral processing, pharmaceutical manufacture and quality control, and many other heavy and light industries. This network in vibrational spectroscopy has considerable potential to unleash the high level capabilities and expertise in Australia to drive innovation in improved efficiency and quality of the goods we produce for both the local and international market and to generate new industries.

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

Data for Research and Discoverability

Question 33 Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.

AUSTRALIAN VIBRATIONAL SPECTROSCOPY RESEARCH NETWORK

EXECUTIVE SUMMARY

- Australia has a strong internationally recognised reputation in vibrational spectroscopy and a vibrant research community that holds its own conference (ACOVS) with many local and international participants from universities, government laboratories and industry.
- Vibrational spectroscopic methods are used by the world's leading manufacturers and research organisations for better understanding of products and processes, giving them a clear market advantage over those who do not use such technology, which needs to be further developed in Australia to provide businesses with the same advantages as their international counterparts.
- Federal and State Governments have already invested heavily in state-of-the-art infrastructure in Government research institutions and the Australian Vibrational Spectroscopy Research Network aims to provide better awareness of such facilities for new and existing Australian organisations. An integrated University-Research Organisation model will enhance the quality of scientific outputs (fundamental and commercial) of these outstanding existing facilities resulting in Australia's ability to become smarter in front-line research and industrial practice and more competitive on a global scale.
- The network will be centred around one node in each state that would be responsible for integrating a state-based network of facilities and expertise to coordinate infrastructure plans and drive innovation in the field for both fundamental science and leading-edge commercial and agricultural advances that will enhance Australia's competitive edge. The Directors of each node would then coordinate these developments into a rolling national roadmap for enhancing the international standing of the research community and develop a strategy for strong engagement with industry and other stakeholders.
- Education and awareness are keys to success and in this capacity. The nodes would be training facilities with the aim of broadening the user base of national facilities (such as the Australian Synchrotron and inelastic scattering at ANSTO) and provide informed advice as to which facility will provide the right capabilities for the problem at hand.
- Collaboration is essential and the proposed network would engage with Australia's Industry Growth Centres and major user communities in Medicine, Agriculture, Mining, Museums, Art galleries, Advanced Manufacturing and the Pharmaceutical as well as the research community to drive innovation based around the infrastructure.
- The funding would support: (i) major national research vibrational infrastructure in University nodes that does not currently exist, e.g. CARS, Raman Optical Activity and other cutting-edge infrastructure; (ii) access programs (travel and user charges where appropriate); and on-line training programs that would be incorporated into the highly successful MyScope platform developed by the AMMRF; (iii) provide an central facility for expertise in chemometrics for data mining from information-rich vibrational spectroscopy and spectroscopic imaging and innovative on-line and ex situ process control.

INTRODUCTION

This position document directly addresses Question 1 of the National Research Infrastructure Roadmap with regard to whether other capability areas should be considered. Australia has a strong internationally recognized reputation in vibrational spectroscopy and a vibrant research community that holds its own conference (ACOVS see https://acovsandasc.wordpress.com/ for the last one) with many local and international participants from universities and the instrument industry and this is also recognised by the award of a range of international conferences in vibrational spectroscopy (International Conference on Advanced Vibrational Spectroscopy, Melb, 2009; the International Conference on Near Infrared Spectroscopy in 2019, the International Conference on Raman Spectroscopy, Gold Coast, 2004; Workshop on Infrared Microscopy and Spectroscopy, Lorne 2013; Shedding new light on disease (SPEC2012) – run by Monash spectroscopists in Chiang Mai, Thailand). This reputation has been built on localised facilities that are found in many universities, government laboratories and industry that have a range of high-end and routine instrumentation, as well as high profile national facilities: i.e., the FTIR beamlines at the Australian Synchrotron and the inelastic neutron scattering beamlines at ANSTO associated with the research reactor.

Everything around us is made up of matter, which produces specific vibrational spectroscopic (mid and near infrared (IR & NIR), and Raman) signatures due to vibrations of its chemical bonds. As such many areas of fundamental research and industrial R&D and process control benefit from vibrational spectroscopic studies on what are often complex mixtures. Because of their importance in the characterisation of chemicals and materials, relatively cheap and user-friendly Fourier transform infrared (FTIR) spectrometers are found in teaching and research labs in Chemistry, Chemical Engineering, Agriculture and many other scientific laboratories and university and technical education institutes. Thus, there is a large number of graduates from these institutions who have a fundamental understanding of the principles of the technique and practical experience before going into the workplace. However, this routine use of vibrational spectroscopy is only a small fraction of the capabilities of advanced high-end FTIR, Raman and near infrared (NIR) equipment and techniques that can tackle complex problems that cover most research disciplines. These include Primary Industries, Arts, Sciences, Medicine, Mining and Engineering and their use by specialists in the field are important drivers to a more innovative and more energy efficient future for Australia. However, the complexity of the use and analysis of data from many high-end instruments available in research institutions have limited use beyond specialist in the field. This is because of lack of sufficient resources to allow for general access programs, apart from the Australian Synchrotron and ANSTO facilities and a few university facilities. Hence, the proposed network is designed to unleash the potential of this large capital investment and highly skilled expertise to give Australia an area of competitive advantage in the many areas of research, development and translation for which vibrational spectroscopy and spectroscopic imaging can make a significant impact. For example, the pharmaceutical industry has encouraged industry to adopt the latest, state-of-the-art technologies and control systems to become more innovative in their quest for higher quality. This is known as the Process Analytical Technology (PAT) initiative of which vibrational spectroscopy makes up the majority of the techniques currently employed.

Countries such as the US and Japan have recently implemented vibrational spectroscopic solutions into state of the art continuous manufacturing systems that reduce factory space by 90%, reduce energy costs by 60% and are 500 time faster in manufacture than current batch manufacturing systems, (pqri.org/wp-content/uploads/2015/11/Embiata-Smith.pdf). With the rapid loss of traditional manufacturing to offshore locations because of cost, Continuous Manufacturing based on control through vibrational spectroscopy will allow Australia to develop similar systems in smarter manufacturing systems that ultimately lead to the creation of new businesses, jobs and IP that can be kept in the country and licensed out to other countries when needed.

This infrastructure position document describes a blueprint to mobilise this cohort of tertiary trained graduates to take full advantage of Australia's leading-edge vibrational spectroscopic infrastructure, techniques and expertise. The vision is to drive innovation in both fundamental and translational research and development in order to create new opportunities and take Australia into a 21st century industrial paradigm.

Apart from the Australian Synchrotron FTIR and ANSTO neutron facilities; there is a range of high-end instrumentation ($0.5-2M) obtained from LIEF and other funding sources that is situated in many universities and other organisations. Generally, the complexity of the instruments and issues with appropriate sampling and the use of data mining tools on information rich data sets obtained from these techniques precludes the non-specialist user from gaining full value from access to the facilities and this can only be achieved by providing the necessary support mechanisms (industry experts, professional officers and technical officers and also maintenance and procurement programs to enable a viable general user access program). Supporting this access will also require the establishment of training facilities that will educate end users to be more innovative and accepting of new technology to improve their day to day tasks. This potential has been recognised by the University of Sydney, which would lead the Network (in collaboration with nodes in all of the states) through substantial investment in its Vibrational Spectroscopy Core Facility (VSCF).

The VSCF has grown rapidly since its founding in 2014 to include a part-time Director, a Facility manager, one full-time and two part-time professional officers and a technical officer as well as fifteen high-end instruments in place or on order, with many specialist accessories. This rapid expansion has been driven by user demand both internally and externally (universities, research institutes and commercial end users), who have partially funded the VSCF through user access fees. Many others would like to use the facilities but are bound by economic constraints and there are other research communities who have expressed an interest in its use but we have not been able to develop a user base as yet because of the demands of accommodating this rapid expansion. This experience of the VSCF demonstrates what a rapid impact a federal investment in a nation-wide network of vibrational spectroscopic infrastructure and access programs throughout Australia would have. Other universities, such as the UNSW and Monash University, have sufficient staffing for limited user access programs for their facilities but not on the scale of the VSCF that could accommodate their large potential user base in a way that would fully capitalise on their high-end instrumentation and expertise. For the many other high end instrumentation found throughout institutions in Australia, access often relies on training and collaboration with the academics in charge of the instrumentation, which normally limits access to only expert users.

EXISTING FACILITIES THAT WOULD BE INCORPORATED INTO THE NETWORK

Below is a summary of the proposed network including existing capabilities that each would bring to the Network.

NSW Facilities

VSCF, University of Sydney

The University of Sydney would be the administering institution of the Network with its Director, Professor Peter Lay. It would contribute existing staff as outlined above and will include the following instrumentation:

- Three high-end Raman spectrometers (one interfaced to a Scanning Electron Microscope (SEM) and chemical analyser), that will have lasers ranging from the UV to near IR with 3D imaging and a spatial resolution of ~300 nm in both normal and inverted microscopes to measure practically any sample including a live-cell incubator for time-dependent studies on cellular processes, variable temperature stages (high and low temperature) and high throughput sampling. A tip-enhanced Raman system with a spatial resolution of 10-20 nm, two portable Raman instruments for fieldwork, an FT-Raman instrument for both mapping and high throughput analysis; a J-Y Raman instrument with a CCD detector and tunable laser for excitation profile studies, solution dynamics and low-wavenumber spectra;

- Two FTIR mapping instruments including a Bruker Hyperion/Tensor system with an FPA imaging detector and live cell and variable temperature stages, and a portable Lumos mapping instrument; a high-throughput Tensor instrument, with a robot twister accessory for 24 hr unsupervised operation and a Bio-ATR for solution dynamics;
- A Bruker Vertex instrument with various high-end accessories including vibrational CD spectroscopy;
- A portable Bruker Alpha with specialist accessories; and near IR capabilities. It will also provide access to instruments in Medicine (Raman/AFM), Pharmacy (nano-FTIR), Engineering, Physics, and Agriculture.

Expertise in the applications of the techniques covers all areas of research in the Arts, Sciences, Engineering, Medicine and Life Sciences and we have world leading expertise in sampling, chemometrics for complex data mining and statistical analyses, and commercial applications.

ANSTO Australian Centre for Neutron Scattering & National Deuteration Facility.

ANSTO has world-leading facilities and expertise in neutron inelastic scattering. Unlike FTIR and Raman spectroscopies that have selection rules that make them differentially sensitive to different vibrational modes, neutron inelastic scattering has no selection rules and, hence, peaks are observed for all possible vibrations in the spectrum, which provides complementary information.

ANSTO also houses the federally funded Deuteration Facility, which provides Australia with an internationally competitive advantage in vibrational spectroscopy. The C-D stretches are substantially shifted in energy from the C-H stretches and the C-D stretches are observed in a region of the vibrational spectrum where few other species are observed. Hence, deuteration provides an invaluable tool for labelling experiments that involve studies of the distribution and reactions of organic molecules in complex systems whether it be chemical reactions or cellular processes. The vibrational spectroscopic community has not taken advantage of this competitive edge in providing specialist deuterated molecules that cannot be purchased from commercial sources, but this will be addressed by the involvement of this Facility in the network.

UNSW contains a variety of high-end FTIR and Raman instruments that are accessible via the Mark Wainwright Analytical Centre.

Macquarie University researchers have been involved with Raman spectroscopy and other Raman applications for over 20 years. The University houses several Raman systems including a Renishaw Raman microscope servicing a broad range of wavelengths form UV to NIR. A range of Raman applications have been developed, including for optical remote sensing and rapid depth-resolved mapping of water temperature. Knowledge about water temperature and salinity, in both freshwater and marine environments is of great importance in fields such as oceanography, climate change and environmental science. It is vital to validate hydrologic modelling, to provide habitat information about plant/animal species in waterways, and to optimise underwater communications. The team also used the Raman effect for efficient conversion of continuous wave laser beams to important spectral regions such as the yellow and UV-C is a major challenge that becomes severely heightened when high powers are needed. They have recently shown that diamond Raman lasers enable efficient and high power conversion of cw beams by virtue of its outstanding combination of high Raman gain and thermal conductivity.

University of Newcastle/Hunter Medical Research Institute (HMRI). Based at HMRI, the Research and Innovation division of the University of Newcastle have established a team of engineers, software developers/mathematicians, medical and agricultural scientists who run a centralised facility for design, construction, customisation and operation of optical devices, including 405 – 1064 nm raman spectrometers and hyperspectral imaging systems. The University of Newcastle also has numerous Perkin Elmer Spectrum Two FTIR-ATR machines which have been extensively used in agricultural crop screening coupled with the Analytical and Biomolecular Research Facility (ABRF), for chemometric calibrations. Collaboration with industry biologists, engineers and mathematical software developers is allowing bespoke hardware to be matched with customised neural network and genetic algorithm based chemometric frameworks for applied outcomes in medicine and agriculture. The team has also constructed a custom hand-built 3D imaging multi-wavelength lightsheet microscope with upgrades to hyperspectral capabilities underway, which is currently servicing Australian and international research groups and clinicians. The team have experience translating research into commercial outcomes having setup multiple offshoot companies that utilise the expertise in custom optical devices, and a web portal for cloud based machine learning from Raman, FTIR, and NIR spectra and hyperspectral imaging data.

Victorian Facilities

Centre for Biospectroscopy and Vibrational spectroscopy facility, Monash University. This facility has a long track record of providing access to high-end users of vibrational spectroscopy to researchers in the Medical and Life Sciences, Chemistry, Physics and Materials sciences but its instrumentation and expertise goes well beyond these areas of specialisation and they will head the Victorian Node and provide the Deputy Director. There is limited user support for researchers in other disciplines, but with the range of instrumentation and expertise available (including advanced chemometrics) they have the ability to provide a comparable facility as the VSCF in terms of the diversity of techniques and user base that they could service. The facilities have been built up over a number of years through continual school, faculty and university support and consist of: 2 Renishaw Raman microspectroscopy systems with a range of excitation lasers, A Witec micro-imaging Raman system, A Renishaw Raman coupled with AFM for TERS, An Anasys nanoIR spectroscopy system, 2 Agilent Focal Plane array imaging spectrometers, a Bruker Equinox general purpose instrument with multiple accessories' a Quantum Cascade Laser (QCL) system to be installed in Nov 16, Portable IR and Raman systems. This equipment is currently being re-housed as a dedicated facility under a Professional Office in the brand new school of Chemistry building – Green Chemical Futures. There are also facilities (Bruker FPA imaging system, Long path cells, Helium cooled bolometers, enclosive flow cells) housed at the Australian synchrotron IR beamline and available for users.

The Australian Synchrotron, ANSTO's landmark facility in Melbourne, has two outstanding beamlines and expertise to match. One beamline has a high spectral resolution instrument with far IR and Terahertz capabilities for many challenging experiments with materials and gases, with internationally leading capabilities for the study of molecules in the gas phase at cryogenic temperatures. The second IR beamline is dedicated to FTIR microspectroscopy and is used for high spatial - resolution (diffraction limited) mapping of materials at the micron scale, and a specialised imaging capability is also being developed. It has live-cell stages and a large array of specialist sampling and measurement modes that are tuned to a particular problem, including attenuated total reflectance mapping, grazing incidence reflectance and co-localised fluorescence imaging. High temperature and high pressure sample environments are also available.

RMIT: The RMIT Vibrational Spectroscopy Facility (RVSF) is well equipped with a Horiba Raman imaging microscope with 532, 633 and 785 nm laser lines; a ChiralIR 2X vibrational CD instrument optimised for biological and pharmaceutical samples; a 785 nm Perkin-Elmer RamanStation 400; and several infrared spectrometers with a range of sampling accessories (including heated and clamp

ATRs, diffuse reflectance, photoacoustics, diamond anvil, integrating sphere, high T and vacuum equipment) and cells for solids, liquids, gases and biological material. From 2017, the RVSF will also house the first research spatially offset Raman spectrometer (SORS) in the Southern Hemisphere, designed for subsurface measurements for disease diagnostics and foodstuff analysis. Staff at RMIT also have leading expertise in quantum mechanical modelling of vibrational spectra, and of chemometrics analyses.

University of Melbourne: has materials research using Renishaw InViva Raman and Renishaw (UV) Raman spectrometers (Prawer) is supplemented by a variety of more conventional FTIR instrumentation. Expertise in the development of hyphenated techniques using IR spectroscopy (e.g. spectroelectrochemistry) suitable for study of biological and abiological samples over a range of different physical conditions (Best).

LaTrobe University provides a Renishaw Raman microprobe with visible and UV laser excitation source.

Swinburne has advanced teraHetrz facilities

Queensland Facilities

The University of Queensland (UQ) has vibrational spectroscopy facilities within the Australian Institute for Bioengineering and Nanotechnology and the Centre for Microscopy and Microanalysis. Predominately the user base centres around engineers and scientists who have a requirement to characterise a diverse materials that include polymers, cells, minerals, coal, nanomaterials, drugs, milk, bitumen, chemical intermediates and composites. The projects have been a mix of fundamental and industry focused projects. The types of analysis include static analysis, time resolved reaction monitoring, analysis of remote samples (via fibre optics), temperature dependent studies and spatial mapping of heterogeneous samples. Instrumentation at the facilities includes Raman microspectrometers x2 (with heating stage, polarisation and a range of lasers), Fourier Transform infrared spectrometers x 2(with attenuated total reflectance (ATR) accessory, grazing angle ATR for analysing thin films on silicon, grazing angle reflectance for analysing thin films on gold, variable temperature liquid cell, high pressure ATR with capacity to analyses in the presence of supercritical carbon dioxide, near infrared with heating cell and surface plasmon resonance) and a Fourier Transform Raman Spectrometer that is capable of analysing static samples or samples heated in a temperature stage.

Queensland University of Technology (QUT). The Vibrational Spectroscopy Facility at QUT has been at the centre of this field in Queensland for over 20 years. In conjunction with QUT's Central Analytical Research Facility (CARF) it currently houses two Renishaw Raman microscopes with 532, 633 and 785 nm laser sources, a WiTec Alpha 300 Confocal Raman system with 532/785nm excitation, a Bruker FT-Raman spectrometer with a mapping stage and five Nicolet FT-IR systems, equipped variously with a range of accessories including ATR, IR microscopy (with a Continuum IR microscope), hot stage Emission IR and a Near IR remote Fibre Probe. The facility has played a key role in much fundamental and applied research in areas as diverse as mineralogy to polymer degradation, forensic science and materials characterisation as well as providing training in the art of IR and Raman spectroscopy to a large cohort of students many of whom occupy key positions in science, government and industry in Australia and overseas.

Central Queensland University: 1 FTIR and sample presses, 2 FOSS (NIR Systems 6500) with various sample modules (liquid cuvettes, heated holder, spinning cup, rectangular cell transport module, remote reflectance head); Antares FTNIR with various sample modeuls (spinning cup, cuvettes, reflectance probe), Viavi MicroNIR, Zeiss NIR InGaAs diode array module, Numerous Zeiss MMS1 Si

PDA modules, Felix Instruments 'fresh produce' spectrometers (we have an IP licence to Felix on these)

South Australian Facilities:

Flinders University: Witec Alpha 300RS confocal Raman imaging with AFM and near scanning optical microscope Raman/AFM/NSOM, Nanonics AFM/Tip Enhanced Raman Spectrometer (TERS), Nicolet Nexus 870 step-scan FTIR with DRIFT, ATR, photoacoustic, polymer stretching, PM-IRRAS, PM-VLOD and PM VCD accessories, Nicolet iN10MX IR-microscope with cooled MCT, micro-tip ATR accessory, ultrafast mapping capability, Thermo Nicolet Continuum FT-IR Imaging Microscope within the school of chemical and Physical sciences analytical centre and part of Flinders Microscopy.

University of South Australia: FTIR-ATR and Raman microspectroscopy facilities dedicated to surface science.

Western Australian Facilities

Curtin University & University of Western Australia: Applied spectroscopy continues to be a key component of Curtin's established strengths in analytical chemistry. The department of chemistry has recently hired Dr Mark Hackett, a previous PhD graduate from the Vibrational Spectroscopy Facility at The University of Sydney, in a strategic decision to build growth in this research domain. The Department of Chemistry and the Nanochemsitry Research Institute (NRI) at Curtin University houses several key pieces of state-of-art equipment (Nicolet iN 10 FTIR microscope, Nicolet iS 50, and WiTec Alpha 300 SAR with 532 nm excitation). In addition, faculty members within the department of chemistry at NRI at Curtin, specifically, Professor Simon Lewis, Dr Thomas Becker and Dr Mark Hackett, are regular users of the FTIR-microscopy beamline at the Australian Synchrotron.

In addition to management of the Raman spectroscopy equipment housed within Curtin University, Research Fellow Dr Thomas Becker is also the primary point of contact for a WiTEC Alpha300RA+ Raman instrument, with 532, 633 and 785 nm excitation, housed at the University of Western Australia. This equipment is used in a diverse range of research applications, including characterisation of nano-materials, applications to forensic science, and more recently, a growing application to the health science/medical arena". Equipment housed within the University of Western Australia and Curtin University is used by researchers from both institutions, depending on research needs.

Tasmanian Facilities

The Vibrational Spectroscopy facility in the Central Science Laboratory at the University of Tasmania has a long history at the forefront of Vibrational Spectroscopy where UTAS housed one of the first Fourier Transform IR instruments in Australia in the early 1980s. The Facility has been continuously updated and currently houses high end research instrumentation for FTIR, Raman and NIR. The FTIR instrument is a Bruker Vertex 70 with a Hyperion 3000 FPA microscope with numerous options for sample measurements such as ATR and grazing angle objectives. The main Raman instrument is a Renishaw inVia Raman microscope with Streamline which has four different laser excitation lines and the dedicated NIR instrument is a Bruker MPA with numerous auto sampler options and fibre optic probes. This centralised facility is staffed by a Research Fellow and has built up great expertise and new methods in a wide range of applications in Vibrational Spectroscopy such as geology, material science, plant genetics and medical sciences.

FUNCTIONS, IMPACT AND GOVERNANCE STRUCTURE OF THE NETWORK

Functions

The primary functions of the network are twofold:

(i) To provide improved access and broaden the user base (public institutions and commercial entities) of existing high-end vibrational spectroscopic equipment in order to drive the innovation and translation agenda that is required to drive the Australian economy and provide social and health benefits,

(ii) Develop and prosecute a national roadmap of investment in vibrational spectroscopy infrastructure, expertise expansion, and translation into industrial, health, environmental, agricultural and arts & society sectors that will maintain and enhance international leadership in the field.

Access Programs

Funding would be required to enable access for users on a merit basis for use of central facilities.

Governance

The highly successful governance and administrative structure of the Australian Microscopy & Microanalysis Research Facility would be adapted for this research infrastructure network.

RESOURCES REQUIRED FOR ESTABLISHING THE NATIONAL FACILITY NETWORK

Resources

Human Resources

Professional Officers will be funded to train new users and increase the access to current facilities.

Access Resources

Access programs similar to those established by the Australian Microscopy & Microanalysis Research Facility would be adapted. Because of the large diversity of specialised instrumentation and both within states and across Australia, appropriate access and training is required for Australia to gain the full value for such infrastructure to drive innovation in research and development. Many of the facilities currently do not have general user access because of lack of resources for training and assistance with data analyses. A properly funded network will unlock this infrastructure and expertise to a broad range of potential users across universities, research institutions and industry.

Infrastructure Resources

A roadmap for major new instrumentation and capabilities not currently available in Australia will be developed which will include CARS and other emerging techniques, especially in nanospectroscopy. These will be located in central facilities.

SUPPORTERS OF THE PROPOSED NETWORK

The following institutions support this proposal (details can be provided if required). In addition, a range of other institutions have indicated support and would be likely to join a full proposal for a network.

NSW

The University of Sydney (Prof Simon Ringer, Director Core Facilities, Professor Peter Lay, Director, VSCF, Dr. Elizabeth Carter, Manager, VSCF)

Macquarie University (Professor Ewa Goldys, Deputy Director CoE CNBP, Professor Helen Pask, A/Prof Rich MIldren)

ANSTO (Dr. Peter Holden, Director, Deuteration Facility, Dr Anton Stampfl, Australian Centre for Neutron Scattering)

UNSW (Dr James Hook, Manager, NMR Facility (NMR) and Spectroscopy Laboratory (SPECLAB), Mark Wainwright Analytical Centre

University of Newcastle (Dr Antony Martin, Project Leader, Office - DVC (Research and Innovation))

South Australia

University of South Australia (A Prof. David Beattie, Future Industries Institute)

Victoria

Monash University (Assoc Prof Bayden Wood, Director COB and Professor Don McNaughton)

Australian Synchrotron (Dr. Mark Tobin, Principal Scientist, Infrared Beamlines).

University of Melbourne (Dr Stephen Best, School of Chemistry)

La Trobe University **(**Drs Evan Robertson and Adam Mechler, Senior Lecturers, School of Molecular Sciences)

RMIT University (Professor Ewan Blanch, Professor of Physical Chemistry, School of Science)

Western Australia

Curtin University: Dr Mark Hackett (Lecturer), Dr Thomas Becker (Research Fellow), Professor Mark Buntine (Head of Chemistry), Professor Andrew Lowe (Director of Curtin NRI)

University of Western Australia (Professor David Sampson, Professor, School of Electrical, Electronic and Computer Engineering)

Tasmania

University of Tasmania (Dr Thomas Rodemann, Deputy Director of Central Science Laboratory and Research Fellow in Vibrational Spectroscopy Facility)

Queensland

The University of Queensland: (Associate Professor Idriss Blakey, Principal Research Fellow, Centre for Advanced imaging, Australian Institute for Bioengineering and Naotechnology; (Dr Glen Fox, Senior Research Fellow, Centre for Nutrition and Food Science))

Queensland University of Technology: (Dr Llew Rintoul, Vibrational Spectroscopy Facility Coordinator)

Central Queensland University: (Dr Daniel Cozzolino and Dr. Kerry Walsh, members of International NIR Council, Australian Near Infrared Users Group)