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# TECHNICAL CAPABILITY FOR THE HVMS SECTOR: the supply side landscape

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*This work on the 'supply side' has been developed to inform the policy work toward the establishment of the Advanced Technology Institute (ATI). Its purpose is to provide a high level overview of the technical capability across the public science system that may be of relevance to the high value manufacturing and services sector. It covers the nature and distribution of capability and the types of links that organisations have with firms. It does not assess capacity or performance.*

## 1.0 INTRODUCTION

New Zealand's high value manufacturing and services (HVMS) sector is diverse, providing a wide range of manufactured products and services that feed into or support many sectors: agriculture, food, energy, health, communications etc. Firms in this sector are largely driven by demand-pull factors<sup>1</sup>. They tend to watch for developments in the industry or by their competitors, or changes in market and customer needs, and then quickly adopt and adapt technology. They look to their own internal capability first, but then externally (locally and internationally) to providers of specialist services.

As distinct from the 'demand side' (what firms or industry need and want), this paper describes the 'supply side' (the external capability available to firms). It outlines, at a high level, the capabilities<sup>2</sup> that are available and where they are located. This information has implications for the ATI as it will need to meet the diverse and often deep external knowledge requirements of New Zealand's HVMS firms. In doing this there is the opportunity for the ATI to support the best use of existing capabilities across the system.

This landscape is focused on institutions that offer technical or knowledge-based services to firms, or engage with them in research and development (R&D). It does not focus on services that are more business-focused, e.g. international marketing or investment advice, or on the underpinning capability that may be relevant in longer time horizons or for training purposes. The institutions covered are principally public sector institutions (owned and or funded), not private consultancies, though a number of private R&D companies and industry-owned sector organisations are covered.

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1 Deloitte, MSI Demand Study 2012

2 By capability we mean an entity, say an individual, team, organisation, or technology, that has ability to do something - turn inputs into outputs. For the purpose of this paper, capability is discussed largely at an organisational level and relates to technical or knowledge-based outputs.

The information in this paper was gathered through site visits and meetings<sup>3</sup> as well as desk-based research. The work has been used to develop a high level picture of the scope and distribution of capability across New Zealand institutions and, to some extent, their linkages with industry. It was not carried out as a formal review and there was no attempt to assess the capacity or performance of the various groups or institutions or inform decisions that may relate to these aspects.

## 2.0 OVERALL THEMES

### 2.1 Scope of Capability

There is a vast array of technical capability that is relevant to the HVMS sector. It difficult to identify all relevant expertise and problematic drawing boundaries around what is relevant and what is not. The *Powering Innovation* report suggested that expertise of relevance to the HVMS sector should include: biotechnology, processing, electronics and embedded systems, mechatronics and robotics, sensing and scanning devices, medical technologies, advanced materials and manufacturing technologies, marine technology, pharmaceuticals, agri-technologies, digital technologies, and information and communication technology.

Table 1 on the following page was developed from the information gathered through the meetings and site visits carried out for this paper and builds from the list in *Powering Innovation*. It identifies six clusters of capability and, within these, 24 capability fields. This table reflects the HVMS-relevant capabilities identified in the New Zealand system and indicates some of the main institutions involved.

The fields are not intended to be either comprehensive (there will be others that are relevant) or mutually exclusive. They include a mix of technology platforms or knowledge domains, such as sensor technologies, and industrial design, and a range of sector specialty areas such as agri- and medical technologies which draw on and integrate other capabilities.

IRL and the University of Auckland (UA) are recognised as centres of capability for the HVMS sector. But capability relevant to the HVMS sector can be found in all New Zealand's knowledge institutions. This is not surprising. Capability has been developed over the years for a range of purposes: in universities and polytechnics to support tertiary teaching at their local campuses, in CRIs to support their sector's needs, and in research associations to support local and national industry needs.

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3 Site visits and/or meetings were carried out for all universities and CRIs, BRANZ, HERA, Cawthron, Defence Technology Agency, NZBio, Weltec, and MIT.

**Table 1: HVMS relevant capability fields and institutional locations**

<b>CLUSTER</b>	<b>CAPABILITY FIELDS</b>	<b>INSTITUTIONAL LOCATIONS<sup>1</sup></b>
MEASUREMENT	Measurement, standardisation, certification, analytical testing	IRL (including measurement standards role), ESR, GNS, BRANZ, HERA, Cawthron, (and many others offer analytical testing services)
	Automation, robotics, mechatronics	IRL, UA, AUT, UC, MU, VUW
	Materials, including metal, composites, light alloy, plastics, biomaterials, packaging	IRL, GNS, Scion, UA, UW, UC, HERA, TIDA
	Textiles	AgR, AUT, VUW
ADVANCED MANUFACTURING & MATERIALS	Sensors, imaging, vision	IRL, PFR, GNS, Landcare, UA, VUW, LVL, DTA
	Photonics	IRL, UO, UA
	Nanotechnology	IRL, VUW MacDiarmid Institute, UO
	High temperature superconductors	IRL
	Medical technologies / devices	IRL, UA (CMDT), AUT, UC, UO
	Agritechnologies, including precision agriculture	AgR, LVL, MU
	Building / construction technologies	IRL, UA, UC, VUW, MU, BRANZ,
	Marine technologies	UA, MIT
MANUFACTURING PROCESSES	Process control, supply chain management, modelling, applied maths/stats, sustainable manufacturing processes, life cycle assessment	IRL, UA, AUT, MU, UC, VUW, Landcare, Scion
	Design, industrial product design and process/service design, user design	AUT, VUW, UC, MU, Otago Polytech, Weltec
	Prototyping, 3-d printing	AUT, MU, VUW, UA, Otago Polytech
DIGITAL TECHNOLOGIES	Electronics, communication networks and security, wireless, geospatial, acoustics, signal processing	IRL, Landcare, UA, VUW, UC, LU, LVL, DTA
	Digital media	IRL, UA, AUT, UW, UC, UO
	Software engineering	UA, UW, VUW, UC, MU
FOOD, BEVERAGE, & BIOTECHNOLOGY	Food and beverage processing and technologies, including functional foods, nutraceuticals, bioactives and natural products	IRL, PFR, UA, AUT, MU, Riddet Institute, NZFIN
	Industrial chemistry and biochemistry, fermentation, biomanufacturing (biotransformation)	IRL, Scion, UA, MU
	Pharmaceuticals / therapeutics synthesis and manufacturing, human and veterinary	IRL, UA, MU, UO, VUW, Malaghan Institute
	Other biotech products, eg research tools, biopesticides	UA, AUT, VUW, UC, Lincoln, UO
RESOURCES	Resources, including minerals processing, energy systems, geothermal engineering	IRL, GNS, UA, VUW
	Forestry/wood processing	Scion, UC, LVL

<sup>1</sup> Institutions judged to have capability in the relevant field at a group, departmental or research centre level are listed here. Order in list does not reflect capability or capacity.

Abbreviations: AgR-AgResearch, BRANZ-Building Research Association of NZ, CMDT- Consortium for Medical Devices Technology, DTA-Defence Technology Agency, HERA-Heavy Engineering Research Association, LU-Lincoln University, LVL-Lincoln Ventures, MU-Massey University, NZFIN-New Zealand Food Innovation Network, PFR-Plant and Food Research, TIDA-Titanium Industry Development Association, UA-University of Auckland, UC, University of Canterbury, UO-University of Otago, UW-University of Waikato, VUW-Victoria University Zealand.

## 2.2 Purpose of Capability

The capability map in Annex 1 provides a view of the distribution of HVMS-relevant capability. It also describes the units as having one of three different purposes which could be imagined as layers:

- Service provision hubs, brokers or incubators, that have been established principally to support the needs of external firms or industry, and tend to be a key access point for firms (the first layer, shown as green circles);
- Research centres that carry out R&D and usually also provide technical services for both public and firm/industry sponsors (light blue circles), or polytechnics providing industry support services alongside their vocational training roles (turquoise circles);
- Departments or units that focus principally on underpinning faculty research (basic and applied) and teaching (the third layer, shown as grey circles and squares).

This map (and Table 1) shows that HVMS sector-relevant capability is distributed across New Zealand. It does not assess how available and 'fit for purpose' that expertise is to firms or the extent of capacity more generally. We can anticipate that firms may, in some instances, be seeking specific expertise that can be provided from an individual or a facility. In other situations, there may be a need for a larger critical mass of resources to support larger projects. The ATI will need to build its own knowledge of where it can provide capability and where this may be better sourced from the wider system.

There was some indication in our discussions that institutions were willing and able to provide more support to industry if the demand is there. For example, analytical and product development facilities in universities could be made more available provided there are sufficient skilled technicians and within the constraints of their usage for teaching and research purposes.

Existing firm-facing units are of particular interest to the ATI, both as models for how the ATI may engage with and provide services to firms, and examples of capabilities that are already positioned in the system to support HVMS sector.

## 2.3 Research activity

Public research investment is another indicator of capability (and to some extent also capacity). MSI investments in this area are funded predominantly through the Manufacturing and Resources portfolio through annual funding contests. Total investment in this portfolio is around \$60m/annum and is across the range of areas shown in Table 2 (over page). This table indicates the pattern typical of investments in this portfolio; IRL is a key research provider, typically carrying out about a third of the research in this portfolio. University of Auckland is also prominent, contributing particularly in pharmaceutical research.

This data does need to be interpreted with caution as there are a range of other sources of funding (eg other MSI investments, HRC, Marsden, TEC, industry sources) that will support capability relevant to the HMVS, as will student EFTS-based funding. As well as this investment, there is additionally around \$70m per annum allocated to firms for business R&D, through the High Value Manufacturing and Services output expense. In some of these cases, research organisations may be supporting firms with R&D and technical services.

**Table 2: HVMS contracts awarded by FRST 2010/2011 (\$m/annum Excl. GST)**

Science area	IRL	PFR	UA	UW	VUW	UC	UO	other	TOTAL
Nanotechnology	1.9				0.4			0.3	2.6
High temperature superconductor	5.6								5.6
Optics Imaging	3.9				0.8	1.1	1.6		7.4
Materials	1.6		2.5					3.5	7.6
Sensors		1.8	0.3		1.7			0.7	4.5
Composites			1.3						1.3
Light Metals				0.9					0.9
ICT	3.8		0.9	2.6	0.4	0.4		1.2	9.3
Pharmaceuticals	5.9		6.5		0.2		3.0	0.7	16.5
Medical technologies	1.6		0.9				2.9	0.6	6.0
<b>TOTAL</b>	<b>24.6</b>	<b>1.8</b>	<b>11.4</b>	<b>3.5</b>	<b>3.4</b>	<b>3.6</b>	<b>6.2</b>	<b>5.5</b>	<b>61.7</b>

## 2.4 Science-Science linkages

For simplicity, the map in Annex 1 does not show the interconnections between institutions or units through partnerships, networks or other distributed organisational forms. There does, however, appear to be a growing trend, across both universities and CRIs, for research capability to be organised in this way. This is evident, for example, in the distributed capability of the MacDiarmid Institute Centre of Research Excellence, the UA Materials Accelerator, the Lighthouse Platform (photonics and optics), the Consortium for Medical Device Technologies and the Mosaic (digital) Innovation Network of the metro polytechnics. Apart from the more long-standing MacDiarmid Institute, these initiatives have been established over the past three years.

Despite these developments, recurring themes in our discussions were that there were still connectivity gaps across the science system, and that a better networked system could more readily form research collaborations, help firms to access the best expertise across the system, and match capacity with demand. This was also a finding in *Powering Innovation*. This connectivity gap was often associated, not with contracted research projects, but with the networking that may occur upstream or around the outside of research projects<sup>4</sup>.

In general, organisations we met with considered the ATI could play an important role in facilitating system-wide connectivity through these sort of mechanisms. They were, however, concerned that the ATI adds value to the system and not act as a gatekeeper or cut across existing relationships.

<sup>4</sup> MSI grants do not generally support networking outside of what is required for particular research objectives though this has been introduced in some recent contracts, eg the Technology Development grant used to support the Lighthouse Platform.

## 2.5 Science-industry engagement

Amongst CRIs, the primary industry-focused CRIs (PFR, AgResearch and Scion) have extensive relationships with large sector groups and firms, such as Zespri, Fonterra, and Carter Holt Harvey. They also have strong links with international firms, such as Nestle and Heinz Watties. Their interaction with smaller New Zealand firms is more limited and tends to involve the CRIs in a capability-building role. Some CRIs have small, specialised units that support the HVMS sector, such as the agricultural services group at Plant and Food and the packaging team at Scion.

Universities have wide relationships with industry. Most links are driven by teaching needs, and increasingly also through initiatives of entrepreneurial student cohorts, such as the Auckland- and Wellington-based Chiasma group. Engagement is also integral to applied research activity and also occurs through consultancy services. The University of Auckland has a strong commercial approach with an organisational-level orientation to industry consultancy and partnerships. In other universities, engagement with industry is less formalised.

The barriers to firms (particularly those less research active) engaging with research organisations are well known and removing these barriers is a focus of innovation policy. In the S&I portfolio these barriers are addressed through schemes such technology transfer vouchers, capability grants, research consortia or other research partnerships.

Our discussions indicated there may be important opportunities for the ATI to further reduce barriers by providing, what was described to us by some as, 'safe spaces' for firms. These were described as collaborative forums or working spaces which allow firms to interact with researchers and amongst themselves without pressure for commercial and research commitments. They are similar to the 'open lab' concept used overseas. There are already a number of examples of these in New Zealand, such as the Affect design program (MU), The LightHouse Platform (UO,UA), and the dialogue initiatives of the Materials Accelerator (UA). These initiatives were understood to provide value to firms as they were accessible, helped them identify common strategic issues (and build industry-wide as well as firm-specific capability), and in some instances acted as a neutral broker. There may be opportunity for the ATI to work with industry organisations or economic development bodies in providing such services.

*The sections that follow provide an overview of the capabilities of the institutions and units/departments within the following groups that play significant roles in supporting the HVMS sector:*

*Crown Research Institutes*

*Universities*

*Research Associations and other Independent Research Organisations*

*Institutes of Technology and Polytechnics*

*Industry Organisations and Economic Development Agencies*

### **3.0 CROWN RESEARCH INSTITUTES**

Crown Research Institutes (CRIs) perform basic and applied R&D, carry out science and technical activities (eg data collection, analysis) and maintain and provide science equipment and facilities that support their particular sector and meets their Statement of Core Purpose. As well as carrying out government-funded activities, CRIs also provide commercial services to firms and undertake collaborative R&D with firms or industry. CRIs engagement with industry tends to be with industry bodies, larger R&D capable firms, or high growth SMEs. The new Technology Transfer Voucher scheme is, however, opening up channels of R&D support to smaller, or less capable, organisations and mean that CRIs (and other providers) can offer their services in different ways.

IRL is the CRI most directly involved in the HVMS sector with the largest science and research capacity. Plant and Food Research (PFR), AgResearch and Scion also provide some support for the advanced manufacturing innovation needs within their particular sector.

*The following sections provide an outline of the capability relevant to the HVMS sector in each of the CRIs and can be referred to as background for the map in Annex 1.*

#### **3.1 IRL**

IRL's capabilities are diverse, reflecting the heterogeneous nature and needs of New Zealand industry. It is organised into three clusters: Advanced Manufacturing Technologies, Industrial Biotechnologies and Measurement Standards, each of which maintains R&D capability and provides a range of technical services to clients.

IRL has capabilities in the technology platform areas of: manufacturing, production and process engineering technologies; materials, energy, and minerals technology; electronic and information engineering; measurement standards; industrial chemical and pharmaceutical manufacturing; and medical technologies.

Within these technology platform areas, IRL has a number of distinctive or unique to New Zealand capabilities, including:

- Digital signal processing, and its application to industrial electronics and automation
- 2D/3D high frequency ultrasound and optical imaging, principally for medical applications
- Digital rehabilitation technologies
- High temperature superconductor technology

- Nanotechnology and microfabrication
- Design and synthesis of high value / complex carbohydrate for pharmaceutical sector, including the commercial Glycosyn facility
- Supercritical fluid extraction for bioactives extraction and nutraceutical or natural products development
- Measurement Standards Laboratory, New Zealand's national metrology institute with responsibility for ensuring appropriate standards as required under the Measurement Standards Act 1992.

IRL is also active in a number of national research initiatives that extend their capabilities, networks and impact including:

- MacDiarmid Institute, which includes four IRL staff amongst its 35 principal investigators
- Consortium for Medical Devices Technologies, set up through an IRL-UoA partnership
- The Lighthouse Platform, focused on industry engagement around photonics and optics and in partnership with University of Otago and UoA
- Biomolecular Interaction Centre, a University of Canterbury (UC) centre, whose co-director Professor Juliet Gerrard has been appointed as an IRL industry outreach fellow
- New Zealand Wireless Research Network, in partnership with UoA and UC
- Ovine Automation Ltd, a research consortia developing robotics for the sheep processing industry.

Apart from the more long-standing MacDiarmid Institute, all of these network initiatives have been established during the past 2-3 years.

IRL's New Zealand industry links includes large players such as Fonterra and New Zealand Pharmaceuticals, as well as many other smaller industry partners. The identification of industry needs and alignment of capability is being progressed through initiatives such as IRL's co-investment fund and the What's Your Problem New Zealand competition. The Consortium for Medical Device Technologies is an example of a new initiative aligned with and designed to support New Zealand's emerging medical device industry. It supports a range of industrial partners, provides a portal for them to access expertise and a means to coordinate research activities. IRL's Carbohydrate Chemistry and Glycosyn groups have connections with international, as well as New Zealand, firms. IRL's Measurement Standards Laboratory works with a large number of companies and this broad engagement provides the opportunity to better understand the measurement and other needs of firms.

### **3.2 Scion**

Scion's sector focus is forestry and wood products. In relation to the HVMS sector, Scion has relevant capability in the development of novel high value or industrially useful biomaterials from wood (and non-wood) products for industry use (energy, plastics, etc). Finding high value uses for wood waste products (eg lignin and tannins) and other waste streams (eg food and agricultural waste) is a key goal, and supporting this are capabilities in the use of renewable resources using green chemistry and clean processing approaches including a range of pilot plant facilities, eg biorefinery, fermentation plants. Scion has developed (and is in the process of commercialising) a technique for dewatering radiata pine



which gives it valuable new material properties. Scion has also developed niche capability in packaging, with a strong focus on primary sector products. It also has a large mechanical pulp refining plant used to explore new product or process opportunities with wood pulp.

The Biopolymer Network is a company-structured R&D collaboration between Scion, AgResearch and Plant and Food Research. It has a focus on commercialisation of technologies and carries out R&D toward high value bio-based polymers, such as the development of bio-foams (derived from polylactic acid) as an 'eco' alternative to polystyrene.

Scion's industrial biotechnology group has similar capabilities to IRL, and both see the opportunities in biotransformation (ie using microbial or genetic systems to manufacture high value compounds) and related green chemistry approaches. At present, Scion has a focus on land-based, large-scale bio-resources (eg use of wood waste streams) while IRL's capabilities lie in design and synthesis of compounds characterised by a higher value to weight ratio, eg fine chemicals, drugs and bioactives.

### **3.3 Plant and Food Research**

Plant and Food Research is organised into four groups: breeding and genomics, bioprotection, sustainable production, and food innovation. Its primary focus is on pre-harvest R&D, notably breeding and genomics through the development of plant cultivars, their protection under plant variety legislation and the transfer of that technology to growers, eg the JAZZ apple. Bioprotection is another key strand and one that is a focus at present with regard to management of the PSA infection of kiwifruit. Plant and Food Research's sustainable production and food innovation groups have some activity relevant to the HVMS sector. Research capabilities within these include bioengineering, particularly the development of sensor systems for food manufacturing, eg smart labels of fruit packaging to detect fruit ripeness, and exploration of bioactives and their opportunities for added value foods.

Plant and Food Research's engagement with industry is focused on work with the large New Zealand-based sector groups, such as Zespri, and international food companies, such as Nestle. It does engage with New Zealand SMEs in the food sector but this is on a small scale and their role is largely one of supporting their capability building.

### **3.4 AgResearch**

AgResearch's capability is largely focused on on-farm production systems, including animal productivity, forage and environment usage. While they have links with agri-technology companies such as Gallaghers and Tru-Test, this on-farm activity has fairly limited emphasis on support for the HVMS sector. Off-farm R&D is carried out by their Food and Bio-based products group and supports the development of high value products from meat and wool with capabilities (Lincoln-based) covering engineering, product development and manufacturing. AgResearch's textile science team, for example, have developed a new dyeing process that allows blocks of colour to be dyed into the wool in a single-set dyeing process, rather than just printed on the surface. AgResearch also offers an Innervision CT scanning service for agricultural applications, eg breeding stock evaluations, provided through a joint venture with Landor.

Like Plant and Food Research, AgResearch has strong engagement and strategic alignment with large sector groups, such as DairyNZ, and some large firms, but limited engagement with smaller firms.

### **3.5 GNS**

GNS capability relevant to the HVMS sector is centred on the National Isotope Centre (housed at GNS) and its Ion Beam Analysis Research Laboratory. This facility enables nanoscale and atomic level analysis and fabrication and supports the development of advanced materials and sensor devices. GNS has also developed a series of 'IsoScan' scanning devices which allow non-invasive scanning of moisture, density, chemical composition with applications in a range of industries, foremost in the timber industry.

The remainder of GNS' business is focused on understanding resources and hazards and is of less direct interest to the ATI.

### **3.6 NIWA**

NIWA's capabilities are in marine, coastal, climate and atmosphere science and their application to areas such as weather forecasting, climate modelling, aquaculture and fisheries, and management of natural hazards such as river flooding and tsunamis. NIWA has linkages with iwi and Māori business interests, particularly those related to Māori-owned fishing assets and operations. In the energy field, NIWA maintains a range of energy asset and demand databases, and has several bio-fuel R&D projects. While not focused specifically on support for HVMS firms, NIWA does, however, have capabilities in data collection, analysis, and management, including remote sensing and high performance computing that may be relevant to some manufacturing applications. The potential role of NIWA, and the climate and marine sector more generally, as a user or demonstrator of HVMS sector products may also be relevant to the ATI.

### **3.7 ESR**

ESR supports New Zealand's public health and justice system with scientific analysis and advice, particularly as it relates to communicable, food and water borne diseases, water quality, food safety, forensics and biosecurity. ESR also operates two nationally important data banks – the DNA and Infectious Diseases bank. The Ministry of Health and Police are key clients. ESR's main business is science services, but this is underpinned by research activity. ESR also hosts the National Radiation Laboratory based in Christchurch which provides radiation testing services. ESR expertise relevant to the HVMS sector is likely to be in relation to food safety or medical product or system testing, either for development (and regulatory approvals) or post-market surveillance. ESR was for example involved in the development of ZyGEM, a New Zealand company (based at Waikato Innovation Park) offering a range of products and services for rapid and/or complex DNA extraction for bioanalysis (eg for forensics).

### **3.8 Landcare Research**

Landcare has capabilities in environmental research, data collection and management and a focus on sustainable land management, biodiversity and pest control. Its informatics team has expertise in the development and application of mapping and satellite-based remote-sensing services providing data and image processing on soils, geology, biodiversity, river catchments etc for land survey use. Information is available publicly through a geospatial information portal and more in-depth expertise available through their consultancy services.

While this remote-sensing and mapping capability principally relates to its role in environmental management, not firm development, Landcare does have significant contact with businesses that operate in the land and agriculture sectors. Landcare's sustainability and society science team provide a range of advisory services and technical tools to support social and environmental sustainability in businesses. This includes the carboNZero programme developed by Landcare, an internationally recognised (carbon footprinting) greenhouse gas certification scheme.

## **4.0 UNIVERSITIES**

Universities carry out basic and applied R&D alongside their teaching functions. Capability relevant to the HVMS is concentrated in those universities with large engineering schools and has evolved to integrate capabilities across the disciplines of engineering, chemistry, physics and biology.

University engagement with industry is largely driven by the needs of the universities to identify industry projects for their students. This is particularly the case in the engineering schools where there is a tradition of practical experience and relationships with local industry (e.g. Tait Electronics and University of Canterbury). There are also examples of industry working with universities to make their teaching more industry-relevant and enable students to be work-ready (e.g. Orion is working with University of Canterbury). Industry-sponsored professorial chairs (for example Mighty River Power Chair in Geothermal Reservoir Engineering at University of Auckland) are another mechanism of engagement with industry.

Universities engage with industry or firms in public grant-funded R&D projects and are encouraged to support commercial outcomes from MSI's HVMS contracts. In these activities, industry partners may be providing advice in their role as stakeholders or potential users, or may be actively participating in the research. While university staff have commitments to teaching, there is a degree of flexibility that allows their time to be freed up for research activity.

Universities also provide consultancy services to industry on request. These cover a range of activities, such as: access to facilities, analytical testing services, participation on industry technical committees, targeted problem-solving, and contract R&D. This sponsored work tends to be initiated through individual staff contacts and generally not regarded with much importance in universities with respect to professional recognition or career advancement.

Universities did, however, express a willingness to develop further their consultancy services to industry. They were, however, frank about the challenges this presents to the traditional academic culture, but also acknowledged the way in which the current generation of students is creating a more entrepreneurial culture at the universities from the ground up. Staff appointments from industry are another important driver of university engagement with industry and a number of the academics appear to be creating impact through having a 'foot in both camps'.

*The following sections provide an outline of the capability relevant to the HVMS sector in each of the universities and can be referred to as background for the map in Annex 1.*

#### **4.1 University of Auckland**

The University of Auckland's (UA) Faculty of Engineering provides teaching and research in chemical and materials, civil and environmental, electrical and computer, engineering science, and mechanical engineering. Cross-disciplinary research in the engineering faculty is focused in four challenge-based themes: energy, infrastructure and environment, technologies for health, and innovation in manufacturing and materials which also draws in capability across the university. The Faculty of Science includes a range of departments with capability relevant to the HVMS, including biological sciences, chemical sciences, physics and computer science. UA is also recognised for its medical school and its associated clinical, biomedical and health technology capabilities.

Compared with other universities, UA has a stronger commercial focus, supported by Uniservices, and a greater visibility of departmental-level services and facilities offered to external clients. Access to services is available through a joint technology planning process which provides the means to engage with industry, jointly identify their needs, and match that with solutions.

##### Firm-facing units

The Materials Accelerator is a firm- oriented portal providing access to the range of expertise and facilities at the university (and other sites) and joint technology planning and collaborative R&D opportunities. It has a focus on applications in the areas of appliances and devices, construction and transport. Its network encompasses a range of UoA research centres and also has links through to AUT, GNS, IRL, Scion, Victoria University and University of Canterbury. Its industry partners are primarily industry bodies and include HERA, Packaging Council, and Plastics NZ.

The Institute for Innovation in Biotechnology offers firms opportunities for co-location and access to UA expertise in biotechnology and bioengineering.

Uniservices facilitates contract research and access to technical services for firms and other external parties, supports the commercialisation of research including the development of spin-outs where appropriate. It also provides education and training and supports the strategic and practical development of centres of expertise.

##### Applied R&D and technical service units

There are a range of UA R&D centres that are part of the Materials Accelerator network that carry out both R&D and provide technical services:

- Plastics Centre of Excellence
- Hybrid Polymers
- Centre for Advanced Composites
- Light Metals Research Centre
- Research Centre for Surface and Materials Science

Beyond the materials area, other UA research and service centres relevant to the HVMS sector include:

- Industrial Information and Control Centre (I2C2) facility (shared with AUT) focused on manufacturing process R&D
- Yacht Research Unit, and its Twisted Flow Wind Tunnel facility
- Photonics and optics R&D, including the Photon Factory facility
- BIOMEMS Research Centre and the Microfabrication lab carrying out sensing and imaging R&D
- Centre for Software Innovation which spans computer and engineering departments and includes the HealthBots programme partnership with ETRI Korea, as well as a range of capability-building initiatives for the software industry
- Auckland Bioengineering Institute, which builds understanding of physiological processes through application of mathematics and engineering, including software development
- Department of Engineering Science, which has capabilities in geothermal, reservoir engineering, and environmental fluids; bioengineering, operations research, solid mechanics, fluid dynamics, network design and simulation, and signal processing.

Auckland is also host to the student group Chiasma (now also in Wellington) which supports links between science students and high-tech firms through networking and development.

## **4.2 AUT**

AUT has capability in manufacturing processes, design and product development. Their approach to R&D encompasses not only research and development but also a focus on deployment (RD&D) through the application and transfer of technologies to enterprise. AUT emphasise interdisciplinary learning and research, seen for example in the integration of the disciplines of engineering, design, communications, computing and maths, within their Faculty of Design and Creative Technologies.

### Firm-facing units

AUT's Business Innovation Centre provides start-ups with expertise and facilities needed to accelerate their pathway to market and growth.

### Applied R&D and technical service units

AUT's Engineering Research and Innovation cluster consists of four research institutes with capability in manufacturing processes and product development:

- Centre for Advanced Manufacturing Technologies
- Centre for Rapid Product Development
- Centre for Reconfigurable Systems
- Centre for Technology and Innovation Management

AUT also partners with UoA in the I2C2 facility providing capability in systems control.

Other areas of capability at AUT include:

- Institute of Biomedical Technologies which is administered by the School of Engineering but sits within their Faculty of Design and Creative Technologies and carries out basic and applied R&D across three areas: respiratory, cardiovascular and biomedical materials
- Creative Industries Research Institute which includes a rapid prototyping facility
- Knowledge Engineering and Discovery Research Institute (KEDRI). KEDRI develops novel information processing methods, technologies and their applications to enhance discoveries across different areas of science and engineering.
- Textile and Design Lab which supports technology upgrading in the fashion and industrial textiles industry, for example, introducing firms to technologies which can perform digital printing for wool and whole garment knitting
- Millenium Institute for Sport and Health which carries out research and provides services in relation to performance and rehabilitation in high performance athletes
- Centre for Artificial Intelligence which is focused on R&D in the areas of human language technology, speech technology, and robotics
- Kode Biotech Ltd, a spin-in developing and licensing biotechnology to customise cell properties for research and medical applications

### **4.3 University of Waikato**

The University of Waikato has science, engineering and computer science teaching and research capabilities, with links to its surrounding primary sector industry base and local government.

#### Firm-facing units

Most University of Waikato research centres and groups are not themselves strongly firm-facing in terms of offering services and expertise, but access to expertise is handled centrally through the university's Research Hub. Undergraduate and post graduate students were encouraged (and in some cases it is mandatory) to seek semester work with firms and the University has a Cooperative Education Unit which places over 200 students in local employment each year.

#### Applied R&D and technical service units

The Waikato Centre for Advanced Manufacturing (within the Faculty of Science and Engineering) provides a facilitator role fostering research and industry links, and has recently established a teaching and R&D partnership with TiDA, the titanium industry development association based in Tauranga.

Other relevant capability in the Faculty of Science and Engineering includes optoelectronic 'time of flight' technology.

Waikato University's Faculty of Computer and Mathematical Sciences has capability in computer networks, cyber security, data mining, digital libraries, and online language learning.

The University of Waikato also has management teaching and research expertise including relevant areas such as innovation and supply chain management.

#### **4.4 Massey University**

HVMS sector relevant capability at Massey includes engineering, food, agritechnologies, and design and is located across their three campuses in Palmerston North, Albany, and Wellington.

##### Firm-facing units

Massey does not have any clear firm-facing units of relevance to HVMS sector, though does maintain a publicly-available on-line database of expertise for external enquiries.

##### Applied R&D and technical service units

Massey's School of Engineering and Advanced Technology (SEAT) provides teaching programmes in engineering, computer science and technology, and construction. They have this year updated their engineering and food technology degrees, making them more focused on industry-relevant practical problem-solving. SEAT also hosts a range of research centres and groups of relevance to the HVMS sector: eg Industrial Management and Innovation, Biochemical Engineering and Process Biotechnology, Electronics, Robotics and Mechatronics, Sustainable Processing, though their focus is research (and allied teaching) not services for industry.

The large (150 staff) Institute of Food, Nutrition and Human Health at Massey University provides a focus for research and teaching in food technology, human nutrition, agribusiness and supply chain management. It has substantial facilities including a pilot plant, food chemistry and product development labs. The Institute provides access to these facilities for firms with most engagement through student research projects. For example, in 2010: 23 companies funded food-related projects with 4<sup>th</sup> year students.

The Institute also encompasses the Riddet Institute, one of the COREs, with capability in the development new and novel functional foods. The Riddet has a wide span of activity including fundamental and applied research, commercialisation, industry consultancy and product development services and networking. Contract R&D make up 25% of their business. The Riddet is also a partner in a new PGP project with Agresearch, PFR and Fonterra on advanced foods and engineering. These and other food technology facilities will also be able to accessed through the NZ Food Innovation Network (NZFIN) under establishment. This independent entity will link pilot plant facilities for the food industry across four sites: Auckland, Waikato, Manawatu (including Riddet), and Canterbury.

Massey's College of Creative Arts hosts the School of Design which includes two Institutes: Industry and Environment Design, and Communication Design. While their primary focus is on teaching, rather than R&D or services to industry, they maintain strong links to industry via student projects and host activities which serve to support industry-wide capability in design and its use by wider sectors. The School has 3d-printing capability which supports teaching and is available to industry for prototype development.

Other areas of capability at Massey University include agritechnologies, and veterinary science and technology.

#### **4.5 Victoria University**

Victoria University (VUW) has capabilities in some of the more fundamental areas of science of relevance to the HVMS, including nanotechnology, mathematics, and biotechnology as

well as more applied capabilities in digital engineering and design. Medical science is a growth area for the university and supported through the co-location of the independent Malaghan Institute of Medical Research on the VUW campus. Victoria has close relationships with local knowledge institutions, local CRIs and DHBs, and Grow Wellington.

#### Firm-facing units

VicLink provides a gateway for firms wanting to access university services as well as operating as the university's commercialisation office.

#### Applied R&D and technical service units

VUW hosts The MacDiarmid Institute (for Advanced Materials and Nanotechnology), one of New Zealand's Centres of Research Excellence (CORE) established and maintained through Vote Education funds. The MacDiarmid Institute focuses on basic and applied R&D under five themes:

- nanoengineered materials and devices
- novel electronic, electro-optic and superconducting materials
- functional materials
- soft materials, complex fluids and porous media
- advanced inorganic & hybrid nano-structured materials.

While hosted by VUW, the MacDiarmid Institute has a distributed capability (of around 35 principal investigators) with networks throughout New Zealand, particularly into University of Auckland, Canterbury and IRL, and internationally. The MacDiarmid Institute has recently partnered with Creative HQ to support commercialisation of their science and technology.

VUW capability in nuclear magnetic resonance (NMR) technology has strong links to technology exporting company, Magritek.

VUW's School of Engineering and Computer Science was formed in January 2009 and has a focus on digital engineering. It has research groups in the areas of artificial Intelligence, communications and signal processing, software engineering, evolutionary computation, mechatronics, network engineering each of whom have a range of industry connections, including collaborative research.

The School of Biological Sciences includes the Centre of Biodiscovery which undertakes interdisciplinary R&D focused on natural products and synthetic chemistry, chemical genetics, and proteomics, principally focused toward development of pharmaceutical leads.

VUW's Faculty of Architecture and Design has close links with firms, supports industry-wide engagement with design (eg DesForm conference April 2012) and experience in interdisciplinary demonstration projects such as the First Light House.

## **4.6 University of Canterbury**

The University of Canterbury's (UC) Colleges of Engineering and Science have a broad range of capability relevant to the HVMS sector. Within engineering, Canterbury has an emphasis on electronics and IT, both supporting and reflecting the strong local industry in these areas. (Christchurch has around one-third of the country's electronic equipment



employment, notably Tait Electronics). UC is currently building its organisational emphasis on innovation; it has recently introduced an innovation medal and is developing an innovation strategy. In this area, it sees its main role, not in commercialisation of its own technology, but in transferring knowledge and technology to industry.

#### Firm-facing units

The NZi3 centre was established in 2005 (through the Tertiary Education Commission) and is an IT teaching and research centre aligned with industry. NZi3 provides an entry point for firms wanting to undertake collaborative R&D, support student projects, or access university expertise or facilities. The NZi3 has strengths in software engineering and a number of research centres are encompassed within or networked with the NZi3 (see below).

The Product Innovation Centre is a small unit, hosted by the College of Engineering, which provides innovation support for academic and industry clients. It specialises in design and manufacturing expertise and tools.

The Structural Timber Innovation Company (STIC) is based on the UC campus and has commercialised innovative structural plywood products. It utilises local expertise and operates to develop and support construction industry uptake of the products. STIC is a Research Consortium funded by MSI through the HVMS portfolio and includes a research partnership with UA.

#### Applied R&D and technical service units

The NZi3 centre encompasses or links to the following research centres:

- GeoSpatial Research Centre, which focuses on imaging, sensing, positioning R&D but also offers access to technical expertise, software, hardware and test platforms (eg unmanned aerial vehicles);
- Wireless Research Centre, which has R&D capability related to the development of wireless applications;
- The HITLab, which undertakes basic and applied R&D in human interface technologies.

Areas of particular relevance to the HVMS sector located in the College of Engineering include:

- bioengineering, including biomaterials and tissue engineering (Centre of Bioengineering)
- chemical and process engineering, including food process engineering, bioprocess engineering.

The Electric Power Engineering Centre supports teaching and its alignment with the electricity sector. It also undertakes firm and industry-good R&D and knowledge/technology transfer.

The Biomolecular Interaction Centre was established through a TEC award of \$1.85m in 2007 with further investments made by UC. This centre investigates the molecular basis of biological function with a view to applications in medicine and functional foods. It encompasses UC researchers as well as partner researchers at the University of Otago, Agresearch, IRL, Lincoln University, Plant and Food Research and ESR.

The MARS 3D CT scanner was developed and commercialised through a partnership between the Physics and Astronomy department at UC and University of Otago Christchurch School of Health Sciences. It is an example of the integration of engineering, science and medical capabilities.

#### **4.7 Lincoln University & Lincoln Ventures**

Lincoln University has a focus on land-based teaching and research and is structured into three faculties: agriculture and life sciences; commerce; environment, society and design. The university also hosts the BioProtection Centre of Research Excellence. Capability of relevance to HVMS firms is focused on agricultural and life sciences and includes a mix of commercial contract R&D and some engagement with industry around student masters, PhD projects. Lincoln is working with AgResearch and Plant and Food Research to establish a BioPesticide Alliance – an initiative to pool and offer New Zealand biocontrol technologies and IP to international companies and support local manufacturing of some components.

Lincoln Ventures Ltd (LVL) is a wholly-owned subsidiary of Lincoln University focused on applied R&D and the provision of technical and information services to industry, across the agriculture, horticulture, manufacturing and environmental sectors. It has 32 (FTE) staff from engineering and science backgrounds and specialist expertise in biosensors and imaging (particularly microwave imaging). While historically focused on agricultural engineering and technology they have newer interests in environment and wider industries. Current projects include:

- the development of imaging and sensor technologies for Tokoroa-based Waratah company to apply to their log harvester heads, enabling best-use log cuts and early selection of logs of insufficient quality for timber;
- a sub-surface moisture sensor to detect under-road water enabling road maintenance teams to identify where repairs are needed.

#### **4.8 University of Otago**

The University of Otago (UO) is recognised for its medical, health science and sciences capability and has a strong focus on research excellence.

##### Firm-facing units

The Lighthouse Platform is an initiative of the Dodd-Walls centre (see below) (with IRL as an additional partner) and operates to develop strategy and networks, across research and with industry, in photonics in New Zealand. It has identified over 200 companies in NZ that are likely to be involved in or benefit from photonics technology and is engaging with New Zealand firms through networking and or partnerships.

The UO Centre for Innovation houses both the Research and Enterprise office as well the university's commercialisation office (Otago Innovations Ltd). It provides co-location facilities for firms and or collaboration with university staff through co-location. Current tenants include BLIS, IZON, Pacific Edge Biotech, Photonic Innovations.

##### Applied R&D and technical service units

The Dodd-Walls Centre for Quantum Science and Technology brings together research capability in photonics and optics from IRL, UA and UO and, through an MSI grant, encompasses a partnership with Southern Photonics.

UO has strong capabilities in health sciences, and supports research centres/facilities including the Otago Genomics Facility and the Centre for Bioengineering and Nanomedicine. A number of the health-oriented departments have strong applied and commercial focus to their research. For example, the Department of Chemistry has capability in polymer chemistry and supported the development of wound healing chitosan gel which is now being manufactured by New Zealand pharmaceuticals. The School of Pharmacy has capability in pharmacokinetics and drug delivery systems.

UO Computer Science department has research groups in artificial intelligence, graphics and vision.

## **5.0 RESEARCH ASSOCIATIONS and OTHER INDEPENDENT RESEARCH ORGANISATIONS**

Research Associations (RAs) (and independent research organisations more generally), are industry-supported organisations that carry out R&D toward industry-defined priorities, as well as provide technical and business services, and professional development services. They are mechanisms that function best for sectors with a large number of firms and low levels of differentiation where a small organisation can serve the common 'industry-good' needs of their membership.

Those with most relevance to the HVMS sector are outlined below<sup>5</sup>.

### **5.1 BRANZ**

BRANZ is a 'research, testing consultancy and information resource for the building and construction industry'. They offer a range of appraisal and testing services for building products and systems. Services have become a more important part of their income over time, making up 42% of income in 2010/11 compared with only 2% in the 1970s<sup>6</sup>. BRANZ also develops tools (eg on-line interactive applications and guidelines) to support user-based assessments.

Research projects are selected through industry input and strategic analysis. Their 2012 research and information plan includes a new priority topic of 'automation, industrialisation and new technologies' and a focus on support for earthquake strengthening. BRANZ fund around \$13m of R&D per year and are planning to lead an industry-wide strategy process to support development of the industry.

### **5.2 HERA**

HERA is an industry-owned organisation serving 600 members in the heavy engineering sector. It operates with an elected executive of 12 staff, and a small team of researchers and key personnel. The staff carry out short-to-medium term R&D projects, with topics selected

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5 The Cement and Concrete Association of New Zealand, the Fertiliser Manufacturers RA and the Leather and Shoe RA are small RAs that probably have little relevance to the HVMS sector.

6 *ibid*

through the input of industry advisory panels. HERA's focus is on metals engineering R&D with an emphasis on technology transfer. Their research capability covers the areas of structural and light gauge steel, welding, metals forming. HERA also provides industry training and carries out or coordinates a range of industry advocacy and development activities.

### **5.3 TiDA**

The Titanium Industry Development Association was established in 2009 as a collaboration between a range of government agencies (NZTE, FRST and TEC) and local private companies, notably Titanox. It supports local industry with technical services particularly prototype and pilot facilities and serves to facilitate industry-industry and industry-science links. It has partnerships with universities, notably the University of Waikato, and the Bay of Plenty polytechnic.

### **5.4 Cawthron**

Cawthron is New Zealand's largest independent RO, and focuses on coastal and freshwater resource management as well as development of aquaculture resources and industry. While principally focused on environmental management, capabilities that may be relevant to HVMS sector in Cawthron include: chemical analysis of bioactives and high value product compounds; algal production systems, microbial fuel cells, bioreactor technology and cryopreservation.

## **6.0 INSTITUTES OF TECHNOLOGY AND POLYTECHNICS (ITPs)**

ITPs function principally to provide industry-aligned education and training, both for students and for professional development of those already in the workforce. They have strong connections with local industry and businesses. They also have growing strengths in R&D and technology transfer<sup>7</sup>. They are well-placed to support innovation in the SME sector through technology transfer, using training as well as delivery of technical and business services, and with a focus on solutions and implementation.

The six larger city 'Metro' ITPs have developed a web-based service Innovating New Zealand<sup>8</sup> across six ITPs: Unitec, WelTec, CPIT, Otago, WinTec, Manukau Institute of Technology that connects business with innovation resources (training, expert services, technical services, interns). Within this group of metro ITPs, Weltec and Otago Polytechnic stand out for having dedicated technical services (eg product development) for firms and are covered in more depth below. The Mosaic Innovation Network<sup>9</sup> is a recent initiative of the Metro group designed to support digital innovation in cities. Mosaic identifies opportunities for digitally enabled innovation in New Zealand enterprises and then matches these with technologies and expertise.

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7 Across the metro ITPs there are 170 research-only FTEs and connections with 850 companies (150 large companies, 350 SMEs)

8 <http://www.innovatingnz.org.nz/>

9 <http://www.digitalmosaic.org/>

## **6.1 WelTech**

As well as industry-focused education and training, WelTech has a business services focus through its WelTechConnect office. This office offers three types of services to business: Smart Product, Smart Business and Contract R&D each of which provide links through to WelTec expertise.

## **6.2 Manukau Institute of Technology (MIT)**

MIT provides a wide range of engineering courses, including mechanical and manufacturing, computer, electrical, marine engineering, and networking and mechatronics.

## **6.3 Otago Polytechnic**

Otago Polytechnic has capability in design-led product and service development and hosts the Otago Institute of Design which is a collaboration with UO. This facility offers prototyping and related product design and development services in its Product Development Centre (the Innovation Workspace) and user-centred design services through its 'Evolver' unit. Otago Polytechnic also offers a range of sustainable practice advisory and training services for business (eg Sustainable Practice 360 courses).

## **7.0 INDUSTRY ORGANISATIONS and ECONOMIC DEVELOPMENT AGENCIES**

These organisations are located in, and typically owned by, industry and operate to serve the interests of industry, sectors and firms. For the ATI, these organisations can play a critical role in helping to identify the technology and skills needs by industry and supporting connectivity between ATI and sectors and industry. Their role may be particularly important in instances where the ATI has the opportunity to connect not just with individual firms but identify and provide knowledge and technologies relevant across an industry.

### **7.1 Manufacturing NZ**

Manufacturing NZ is a division of Business New Zealand and provides business, promotion, advocacy and networking services to members. They host the Manufacturing Knowledge Here<sup>10</sup> search engine which can identify manufacturing expertise and facilities in New Zealand universities (not CRIs). This project was supported by NZTE, Manufacturing NZ and Business NZ. They also provide links through to the 'Innovating New Zealand' hub of the ITPs, to IRL, Global Expert, and TechNZ.

### **7.2 Other industry organisations**

There is a wide range of industry organisations that support firms and professionals with sector-related business services, access to expertise, advocacy, and professional development support. These include, but are not limited to: Aviation Industry Association of NZ (Inc), Chemical Industry Council, Composites Association of New Zealand Employers and Manufacturers Association (EMA), IChemE, Institution of Professional Engineers of New Zealand (IPENZ), Medical Technologies Association of New Zealand (MTANZ), Metals New Zealand, Natural Products New Zealand, New Zealand Food and Beverage Exporters' Council Inc, New Zealand High Temperature Superconductors Industry Association

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<sup>10</sup> <http://www.mkhere.org.nz/>

(NZHTSIA), New Zealand Institute of Food Science and Technology Inc, New Zealand Software Association, NZBIO, Packaging Council of New Zealand, Plastics New Zealand, Wood Processors Association of New Zealand (WPA).

### **7.3 Economic Development Agencies**

Economic development agencies such as Auckland Tourism, Events and Economic Development (ATEED), Grow Wellington, Canterbury Employers Chamber of Commerce, and the Tauranga Chamber of Commerce provide business advisory and investment services to local firms. They also collectively form the MSI/NZTE Regional Business Network facilitating access to government programmes of assistance including TechNZ funds.

## **8.0 CENTRAL GOVERNMENT**

### **8.1 MSI and NZTE**

MSI manage the Global Expert service. This specialist service operates to identify local or international experts that can support a firm's needs to evaluate ideas or market opportunities, accelerate product development, solve technical challenges and find new suppliers. Searches are subsidised and cost \$495 for a New Zealand search and \$1995 for an international search. Additional funding is also available to engage experts sourced through Global Expert (\$2000).

Better by Design is a range of programmes and services aimed to support growth and competitive advantage in New Zealand exporting firms through better use of design. The programme includes a range of seminars and workshops, funding to support the use of external consultants and prototyping, and access to design partners. Better by Design is administered by NZTE.

The NZTE Lean Business programme provides support for firms to identify and address opportunities to improve production processes to add value and reduce waste. The programme offerings cover a lean business seminar for senior managers, and \$20,000 financial support (which must be matched by the firm) to engage a consultant.

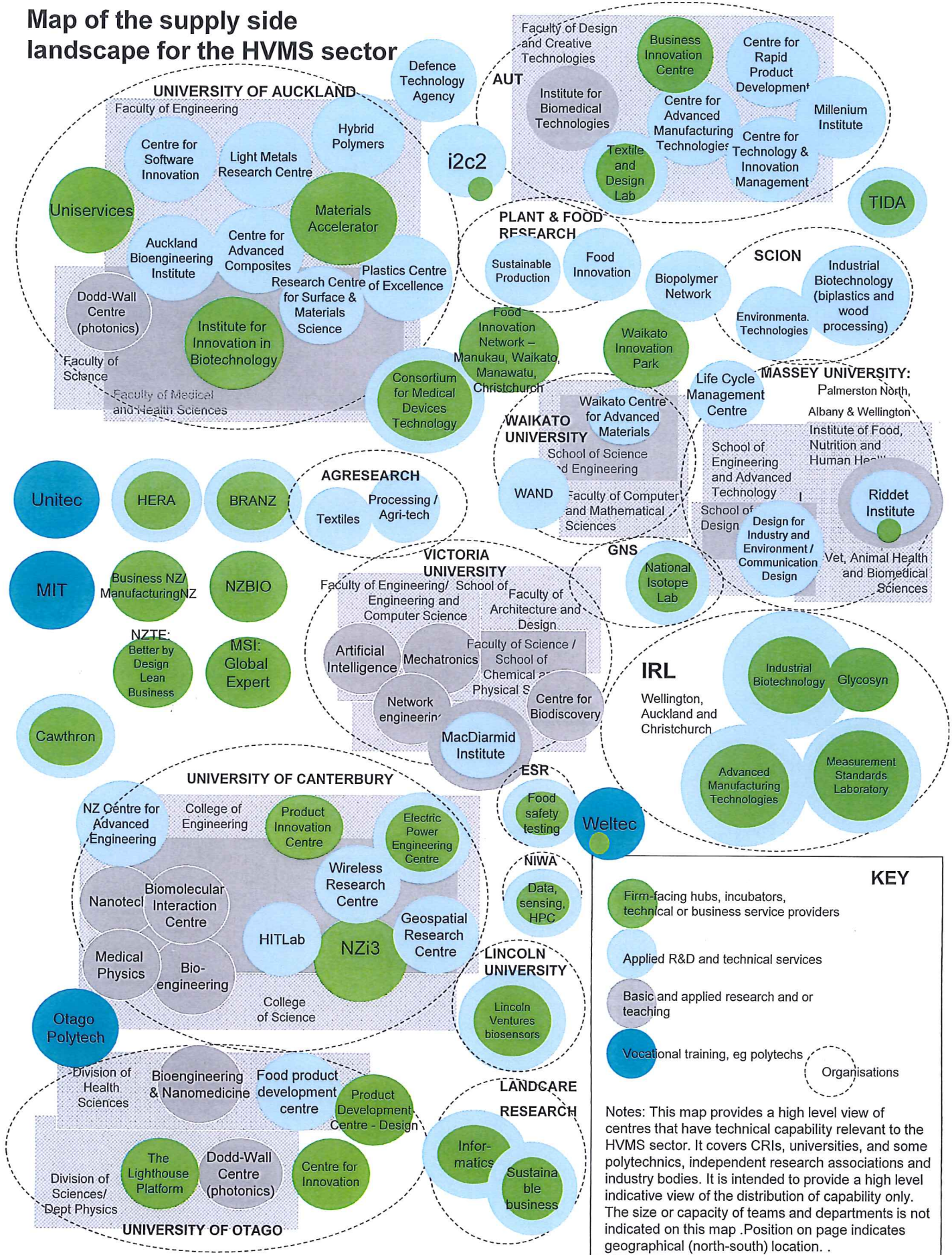
### **8.2 Defence Technology Agency**

The Defence Technology Agency (DTA) is a technical unit of the New Zealand Defence Force (NZDF), with a mission to practice the 'innovative application of science and technology to enable the NZDF to secure and protect New Zealand'. Based in Devonport in Auckland, DTA has 82 FTE, with science competencies in applied mathematics, electronic engineering, materials and mechanical engineering, chemistry and physics. It is organised into four functional areas of: networks systems, sensor systems, applied vehicle systems, and human systems. While the DTA is currently focused on supporting the NZDF, a recent review recommended that it could add more value to New Zealand if better integrated with the rest of the science and innovation system, both domestically and internationally<sup>11</sup>. This included the opportunity for the DTA to transfer knowledge or technology to industry through services, licensing, or through its acquisitions activity which, particularly for dual use technologies, could support local industry development.

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11 Ledson, D; Anderson, H; Jordan, N. Review of the Defence Technology Agency. Applying Science for New Zealand's Security and Prosperity. March 2011.

# Map of the supply side landscape for the HVMS sector



**KEY**

- Firm-facing hubs, incubators, technical or business service providers
- Applied R&D and technical services
- Basic and applied research and/or teaching
- Vocational training, eg polytechs
- Organisations

Notes: This map provides a high level view of centres that have technical capability relevant to the HVMS sector. It covers CRIs, universities, and some polytechnics, independent research associations and industry bodies. It is intended to provide a high level indicative view of the distribution of capability only. The size or capacity of teams and departments is not indicated on this map. Position on page indicates geographical (north-south) location.