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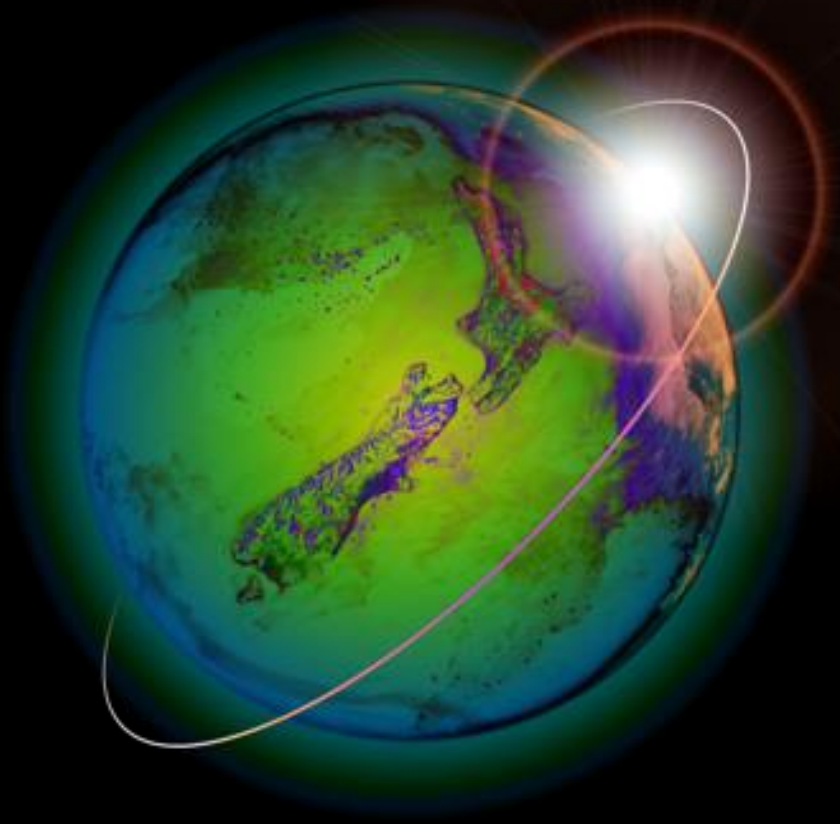

Christchurch Aerospace Sector Plan

Prepared for the Ministry of Business, Innovation and Employment

November 2019

Deloitte Access Economics

Contents

Glossary

Acronym	Full name
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority of New Zealand
CPI	Consumer Price Index
EO	Earth Observation
FSO	Free Space Optical Communication
GIS	Geographic Information Systems
IP	Intellectual Property
MBIE	Ministry of Business, Innovation, and Employment
NZTE	New Zealand Trade and Enterprise
RPAS	Remotely Piloted Aircraft Systems
SBAS	Satellite-Based Augmentation System
SOFIA	Stratospheric Observatory for Infrared Astronomy
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

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Name	Organisation
Roland Sommer	TE Connectivity
Gill DalDin	Christchurch NZ
Richard Sandford	Christchurch NZ
Mark Rocket	Kea Aerospace
Mike Killick	New Zealand Trade and Enterprise
Tim Searle	New Zealand Space Agency/MBIE
Isaac Holliss	New Zealand Space Agency/MBIE

In the attempt to provide a balanced perspective as to the future of Christchurch's aerospace sector, we also sought feedback across a number of different aerospace sub-sectors. We wish to acknowledge the following participants for their time and insightful contributions, via either workshops or interviews:

Core consultations

Name	Organisation
Hugh Reynolds	Fabrum Solutions
Dr. Maria Pozza	Gravity Law
Dr. Avinash Rao	IDS Consulting
Philipp Sueltrop	Kea Aerospace
Dr. Malcolm Snowdon	IDS Consulting
Kurt Janssen	Orbica
Pat Fogarty	Shamrock Industries
Emeline Paat-Dahlstrom	SpaceBase
Eric Dahlstrom	SpaceBase
David Humm	University of Canterbury
Jace Carson	University of Canterbury
Hugh Reynolds	Fabrum Solutions
Dr. Maria Pozza	Gravity Law
Anna Kominik	Zephyr Airworks

Additional consultations

Organisation/name
AMSAT-ZL
Abley
Blinc Innovation
Brush Technology
Christchurch International Airport
Dawn Aerospace
Environment Canterbury
Fleetpin
Hivemind
Invert Robotics
Jayden Hunt
Ministry of Awesome
Mitchell L Gingrich JD
Project Dynamics
RHW Telecommunications
Seequent
Skybase
Tait Communications
Webtools

Executive summary

Christchurch aspires to be at the centre of an energetic national aerospace sector by 2025, with a network of aerospace companies employing hundreds of people across the city.

The aerospace sector encompasses the research and development, design, manufacturing and launch of satellites, drones, flight vehicles, space launch vehicles, and spacecraft (manned and unmanned), as well as upstream and downstream services concerning the provision and use of aerospace data.

With strong government backing and private mandates to invest in education, innovation, and local aerospace entrepreneurship, many nations' aerospace sectors now possess average productivity levels and wages far exceeding their national averages.[1] Aerospace presents an opportunity for the country to harness its entrepreneurial aptitude, trade relationships, and the capability of an already booming technology sector to future proof the national economy.

Christchurch can, and should, play a role in the growth of the national and global aerospace sector. Value is not only derived from the inherent importance of aerospace as an economic sector in its own right, but also the potential benefits that may flow to other sectors that adopt aerospace technology. For example, aerospace technologies may allow primary sector producers to take advantage of position navigation and timing, remote sensors and critical infrastructure to increase living standards and technological progress across New Zealand.

Purpose of this report

The aim of this report is to develop and present a five-year strategic plan for Christchurch's aerospace sector. This Christchurch Aerospace Sector Plan (the "Sector Plan") serves as a first step to accelerate the growth of aerospace in Christchurch, and captures:

- Christchurch's existing strengths in aerospace
- A capability map of the Christchurch aerospace ecosystem
- A set of clearly defined goals
- Action points to achieving these goals
- Recommendations on the initiatives needed to help develop the sector
- Potential regional economic benefits arising from the implementation of the Sector Plan.

The Sector Plan clearly outlines a future direction for the aerospace sector in Christchurch. Our analysis is based on various stakeholder interviews, three stakeholder workshops and an online survey. This information is augmented with additional desk research and data analysis of the Christchurch economy.

Christchurch's competitive advantage

Every region in New Zealand has a role to play in boosting the national economy. Christchurch has to build on its strengths, and one of Christchurch's competitive advantages lies in aerospace.

Christchurch's size is a strength

The power of small brings benefits such as the ease of doing business, and building and maintaining connections. Organisations in Christchurch's aerospace sector actively collaborate with each other, and have already built specialised research capability to support commercial organisations. Christchurch has strong sector, government and academic linkages, and a number of aerospace networks, such as the Christchurch Aerospace Centre and the New Zealand Aerospace Challenge, which are located and hosted in Christchurch. The depth of capability present within Christchurch's

[1] Aerospace Technology Institute. (2018, February). UK aerospace productivity growth strong, but uneven.

tertiary institutes and the reputation of University of Canterbury graduates among aerospace employers is also a distinctive feature of the Christchurch aerospace ecosystem.

The aerospace sector is a small but increasingly important catalyst for Christchurch's economic growth
Through commercialisation, innovation, and skills development, which results in increased productivity, a growing aerospace sector has the ability to support strong economic growth in other sectors by connecting the city to rapidly growing international markets and helping future-proof the local economy.

Christchurch is home to one of New Zealand's largest electronic manufacturing clusters
Christchurch possesses a strong platform for producing aerospace and space qualified hardware, and aerospace-reliant technologies. Christchurch's share of manufacturing relative to other industries is higher than both Wellington and Auckland. Its concentration of manufacturing activity is also 10% and 15% higher than the national average in terms of Gross Domestic Product (GDP) and employment, respectively. This indicates that Christchurch has an existing competitive advantage in manufacturing relative to other regions across New Zealand.

Christchurch has unique physical attributes and access to critical infrastructure
Christchurch's low air traffic and easy access to both an international airport and seaport, make it an ideal environment for the development and testing of aerospace technologies, including sub-orbital rocket launch, drones and satellites. Christchurch is also one of five international gateways to Antarctica and the only one in New Zealand. Antarctica's extreme environment is often used to simulate extra-terrestrial conditions in the testing of advanced prototypes in the final stages of research and development.

Current testing facilities give Christchurch a head start on the global stage
Christchurch offers opportunities for altitude testing. For example, the physical qualities of Birdlings Flat and its proximity to a major city allows for incidental cost reduction and a faster iteration process. However, while Christchurch offers a wide range of public and private environmental testing facilities, the options are non-exhaustive and remain unconsolidated.

Aspirations and key enabling factors

Christchurch's aerospace sector has ambitions of its own. The city aspires to be New Zealand's aerospace hub by 2025, becoming home to a network of successful aerospace companies employing hundreds of people across the city.

Specific ambitions include:

1. To become a globally distinctive centre for aerospace
    i. World renowned in the application of aerospace data
    ii. A world recognised test site for emerging aerospace technologies
2. To be a self-contained aerospace ecosystem, with hardware design, manufacturing, launch and data capabilities

Stakeholder interviews indicated that the key enabling factors required to foster a vibrant aerospace sector include:

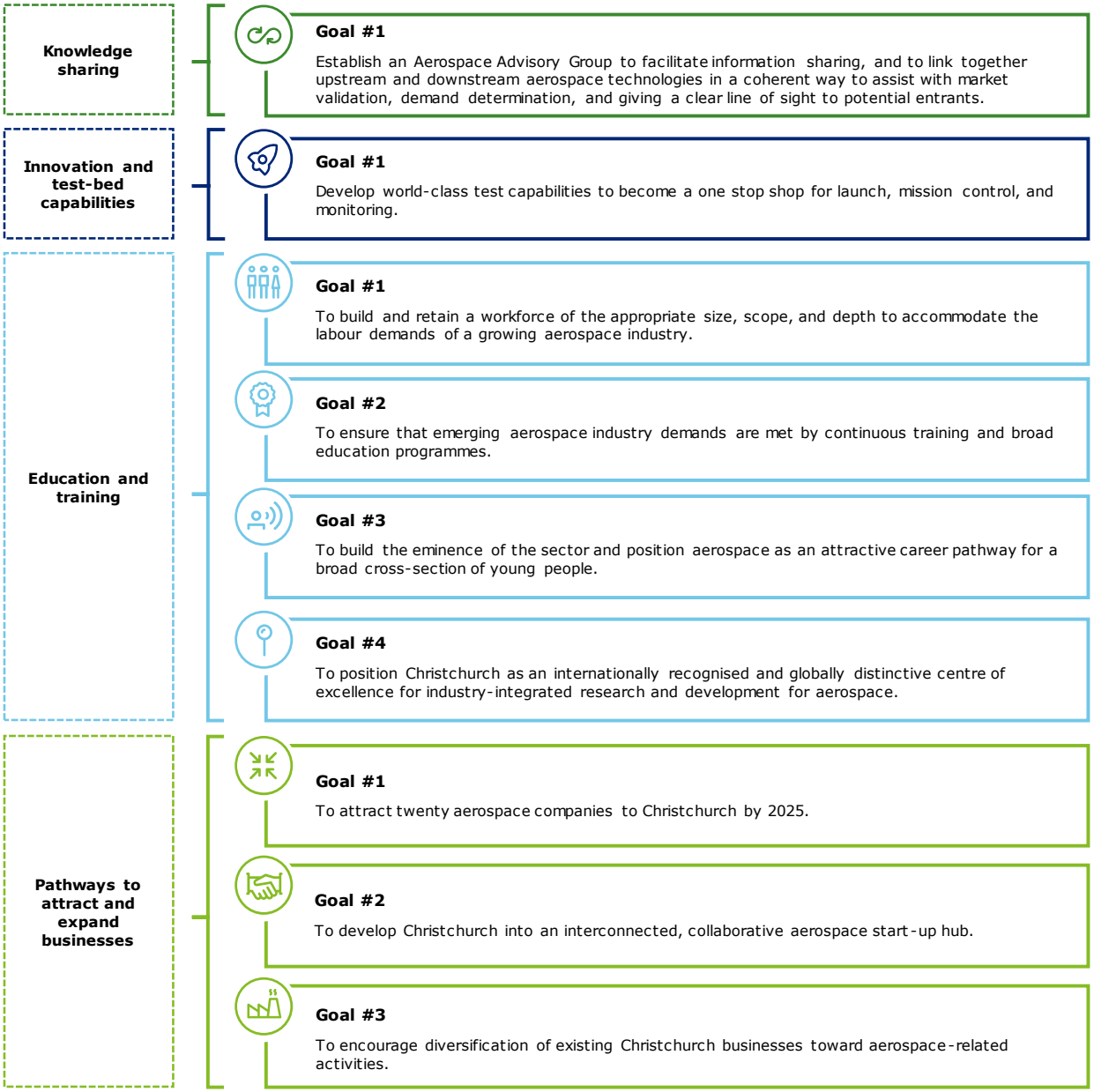
- **Strengthening capability and workforce to ensure that the aerospace sector is positioned for growth**: Christchurch has expertise in almost every segment of the aerospace sector, particularly in niche areas such as advanced manufacturing. However, there exists capacity for growth to attract the right skills to Christchurch, and to create job opportunities in sector.
- **Creating a business environment to attract new businesses and encouraging existing businesses to expand or pivot into the aerospace sector**: Christchurch has at least one player within most levels of the aerospace value chain, but there is significant room

for growth across the aerospace value chain. This growth may be facilitated by attracting new businesses to the city and encouraging existing businesses to transition to aerospace-related offerings.

- **Experimenting through niche expertise and innovation:** Our stakeholder consultations revealed that one of the greatest enabling factors to grow the Christchurch aerospace sector through innovation. A critical driver of this enabling factor is the establishment of a world recognised test-bed facility in Christchurch.

A plan for action

Based on stakeholder workshops and interviews, the Study Team collated a series of goals and action points as a pathway to ensuring that the stated ambitions for Christchurch's aerospace sector are realised.



A further 19 action points are explored in this report. These are categorised as quick wins (achievable within 12 months) and long-term action items (achievable within 1-5 years). For example, in alignment with the aspiration to be world renowned in the application of aerospace data, one of the action points include establishing a Data Cube to address the mismatch between data collection activities and downstream data application.

Recommended initiatives as part of the Sector Plan

As part of the action points and goals listed in this report, the following key initiatives, if enacted, may assist in accelerating the growth of Christchurch's aerospace sector.

1. **Establishing an Aerospace Advisory Group**
   There is a governance gap concerning ownership of the Sector Plan and associated initiatives. Establishing an Aerospace Advisory Group to share knowledge and engage in eminence building activities across New Zealand could bridge this gap, while assuming the overall responsibility of implementing the Sector Plan.
2. **Establishing an end-to-end aerospace incubator**
   Stakeholder consultations consistently revealed the importance of commercialisation and patenting, in addition to deep tech research. Internationally, hardware-specific incubators and accelerators have bridged this commercialisation gap. Similarly, providing hardware, machining, and software development facilities in one place through an aerospace-specific incubator in Christchurch will be central to achieving the city's goal of developing a cohesive aerospace offering.
3. **Establishing testing facilities**
   Establishing full-service environmental testing facilities in Christchurch and offering designated land sites for small- to medium-scale aerial testing has the ability to support local aerospace start-ups commercialise their ideas and attract international businesses to the city.
4. **Establishing a Data Cube**
   To be world renowned in the application of aerospace data, Christchurch-based aerospace companies need to continuously innovate. It is also important to find ways to identify and pursue markets for new data applications in a timely manner. One way to reduce technical barriers for downstream users of aerospace data will be to establish an open source space aerospace data platform, or 'Data Cube'.[2] Acting as a central repository for ready-to-use Geographic Information Systems (GIS) and Earth Observation (EO) data, a Data Cube would build deep capability in value-added aerospace data analysis.
5. **Establishing a workstream to proactively identify demand**
   There is currently a lack in an understanding around existing, adjacent, and new markets, and consumer needs. Demand identification is critical to linking downstream, upstream segments of the aerospace sector, and ensuring that innovation, design, and manufacture of hardware is fit for purpose.
6. **Establishing dedicated funding streams and an annual prize for Christchurch aerospace companies**
   Creating awareness around Christchurch's aerospace sector and attracting aerospace businesses to the city are critical outcomes of the Sector Plan. Establishing an aerospace-specific venture investment fund and a sizeable annual aerospace prize may improve access to funding, particularly for pre-seed stage companies.

Establishing a dedicated funding stream for both Christchurch and New Zealand based aerospace companies. This will most likely be a joint investment by government and specialised local or international venture companies. This model has been highly successful in the agritech sector, where companies such as Finistere Ventures have made multiple investments in early-stage New Zealand companies. Venture capital companies with a demonstrated commitment to space and/or aerospace companies include Khosla Ventures and Bessemer Venture Partners.

[2] Salm, K. (n.d.). Open Data Cube: An Open Data Cube for NZ. Melbourne: FrontierSI.

Regional economic benefits associated with the Sector Plan

Implementing this Sector Plan could build significant capability within the regional economy. Growth in aerospace is likely to boost productivity, create additional jobs, and intensify knowledge spillovers and reputational effects. The adoption of aerospace technologies by primary sector participants is also likely to support more sustainable farming practices.

Christchurch's aerospace sector has a promising future. However, connections and reputations matter, and growing the sector will require a long-term, concerted commitment to implementing the initiatives identified in this report. Indeed, Christchurch must decide on which actions to prioritise over the next five years in order to accelerate growth, ensure that latent aerospace opportunities and the city's wider ambitions are realised.

What's next?

In this report, action points were assigned to core stakeholders to take responsibility for the implementation of the Sector Plan going forward. In our view, it is of essence to establish the Aerospace Advisory Group first to ensure there is overall governance of the Sector Plan.

Aerospace is a global opportunity and, as such, building a resilient aerospace workforce, a robust research and innovation pipeline and strong commercialisation capability will ensure that aerospace remains an economically attractive opportunity by granting access to rapidly growing export markets.

Positioning Christchurch on the world stage as a leader in aerospace data analysis, in particular, will facilitate business transition, business attraction and allow local start-ups to compete internationally through the provision of novel applications for existing aerospace data.

Deloitte Access Economics

1 Introduction

Aerospace occupies a deep and broad value chain spanning the entire economy, from advanced manufacturing, and fabrication, design, and engineering services all the way through to technical consulting and professional services. Aerospace services also provide essential data and information to almost everyone, from Earth imaging to navigation systems. These activities also include the manufacturing of drones and unmanned aircrafts, providing the sector with an opportunity to take advantage of position navigation and timing, surveillance, critical infrastructure, emergency services and the creation of innovative economies to increase living standards and technological progress.[3] Christchurch has an opportunity to capitalise on the growth potential in aerospace, but the question remains – what are the key strategic choices Christchurch faces in order to successfully advance aerospace as a local sector?

In this context, the Ministry of Business, Innovation and Employment (MBIE) commissioned Deloitte Access Economics (the Study Group) to develop an aerospace Sector Plan for Christchurch. A Steering Group was also appointed as part of the project, which included New Zealand Trade and Enterprise (NZTE), TE Connectivity, Kea Aerospace, ChristchurchNZ and MBIE. The objective of this project was to:

- Identify existing strengths of the Christchurch aerospace sector
- Develop a capability map of the Christchurch aerospace sector ecosystem
- Develop a 5-year Sector Plan with clearly defined goals
- Suggest pathways to achieving those goals, and identifying relevant stakeholders that could drive key action items
- Provide recommendations on the initiatives needed to help develop the sector, alongside a discussion around how these recommendations could boost the regional economy.

This report provides the sector with a set of strategies and an actionable plan to achieve the goals identified. Outlining a pathway to achieving these suggested goals also provides direction around the necessary steps and accountability required to ensure the benefits of the emerging aerospace sector are realised for Christchurch within the timeframe set out in the Sector Plan.

Deloitte Access Economics developed a tailored approach to identify aerospace activities in Christchurch, the strengths of the sector, and the opportunities that Christchurch has to offer. To complement existing research and literature on the global and local aerospace sectors, several primary research methods were used to analyse the aerospace sector in Christchurch.

Table 1.1 Primary analysis conducted during this project

Analysis	Description
Sector snapshot survey	A survey was designed to capture a snapshot of Christchurch's aerospace sector. Questions were designed to collect information concerning business and services, the scope of activities, and the key strengths of the sector.
Stakeholder workshops	We facilitated a workshop with key stakeholders with the purpose of identifying key priority areas for the sector, key strategic choices for the sector, goals for the sector and action items needed to achieve these goals.
Stakeholder consultations	We conducted interviews across all of the segments of the aerospace sector and supplementary workshops with sector participants to capture diverse views and bridge any identified gaps.

Source: Deloitte Access Economics

[3] Ministry of Transport. (2018). Taking flight: an aviation system for the automated age.

2 Defining aerospace

Defining the boundaries of aerospace as an emerging sector.

To arrive at our definition for aerospace, we first performed a desktop review of global aerospace literature. We then consulted Deloitte's aerospace and space subject matter experts, and conducted a review process with the project's Steering Group.

The definition of aerospace adopted for purposes of the Sector Plan will guide the strategic choices of the sector, and reflects an emerging sector rather than the current dimensions and activities involved in traditional aerospace.

One of the most complete definitions for aerospace is the OECD's standard definition of aerospace based on Weiss and Amir (2019).[4]

> *"The aerospace sector covers the assemblage of manufacturing that deal with vehicular flight within and beyond the Earth's atmosphere. The aerospace sector is engaged in the research, development, and manufacture of flight vehicles, including unpowered gliders and sailplanes, lighter-than-air craft, heavier-than-air craft (both fixed-wing and rotary wing), missiles, space launch vehicles, and spacecraft (manned and unmanned). Also included among its concerns are major flight-vehicle subsystems such as propulsion and avionics (aviation electronics) and key support systems necessary for the testing, operation, and maintenance of flight vehicles. In addition, the sector is engaged in the fabrication of non-aerospace products and systems that make use of aerospace technology."*

The OECD's standard definition has been altered to better reflect the New Zealand context:

- Our consultations with local participants confirmed that despite Christchurch's rich heritage of aviation, **aerospace for the purposes of this report excludes commercial airline services and aircraft maintenance activities**.
- This definition of aerospace **encompasses downstream technologies that harness aerospace data**, which include ground stations or aerospace-enabled services such as technical analysis and data storage. One challenge associated with a prescriptive aerospace definition is the overlap between aerospace and 'core space' technologies. According to the OECD, the term aerospace describes "all regions beyond the Earth's surface".[5] In consultation with Deloitte's subject matter experts and key participants in the local aerospace sector, the view was shared that **satellites are included in aerospace, although they could also be viewed as part of the space sector**. In this sense, 'space' could be interpreted as a subset of 'aerospace'.
- In consideration of New Zealand's ability to serve as a neutral testing ground, **armaments are excluded from the definition outlined above.** This includes projectiles, explosives and other technologies with exclusive military applications. In saying that, we recognise that the demarcation of some aerospace applications may overly cumbersome. For example, satellite Earth imagery may have been developed initially for military use, but is now heavily used in environmental applications.

[4] Weiss, S. I., & Amir, A. R. (2019, July 11). Aerospace industry.
[5] OECD. (2012). OECD Handbook on Measuring the Space Economy.

3 The global and local aerospace context

Globally, New Zealand is a unique example of an almost entirely commercially driven aerospace sector.

3.1 New Zealand is an attractive destination for aerospace

In the absence of a large defence budget, private players have always been at the centre of the New Zealand aerospace sector. New Zealand's aerospace sector has therefore relied on organic growth and private investment, and has positioned itself as an attractive destination for both aerospace start-ups and large international companies to do business. Emerging fields of expertise include:

- **Advanced manufacturing:** C-Tech, Rapid Advanced Manufacturing, Buckley Systems
- **Subsystems and electronics:** Nautech, Rakon, Tait Communications
- **Satellite tracking:** Awarua Ground Station, Lochiel Ground Station
- **Spacecraft and launch:** Rocket Lab, Dawn Aerospace, LeoLabs (USA)
- **Data and earth observation:** Xerra, Critchlow, Eagle Technology
- **UAVs:** Aeronavics, X-craft, Zephyr

Distance means New Zealanders shrink the world by bringing their skills and knowledge closer to the markets that need them through technology. As such, New Zealand has built a good reputation with international companies wishing to undertake large-scale testing of technologies and research and development activities. This reputation is based on some distinctive aspects, such as the appetite for new technology within the country, a relatively small but well-educated population, and a diverse landscape and climate.

New Zealand is an attractive, open economy where businesses thrive and investment is encouraged. The country ranks first in the World Bank's Ease of Doing Business Index, which is an important source of advantage for the economy. New Zealand also has a straightforward, business-friendly, a tax system that supports capital development and international investment.[6]

New Zealand's high levels of innovation, quality of products and services, and ease of doing business allow aerospace companies to overcome barriers imposed by the country's distance from key markets. New Zealand is in a good position to take further advantage of the opportunities global within aerospace. New Zealand is ranked 3rd for global creativity, 5th in Asia and Oceania for innovation and 6th in the world for its contribution to science and technology.[7]

[6] The World Bank. (2018, May). Rankings & Ease of Doing Business Score.
[7] Deloitte Access Economics. (November 2017). Slice of Heaven: Industries of Opportunity.

3.2 Strong government support for the aerospace sector

Within a short timeframe, New Zealand introduced comprehensive space and aerospace activities legislation - the Outer Space and High-altitude Activities Act (2017) – to accommodate Rocket Lab and other emerging aerospace companies. Rocket Lab built a launch vehicle within a short time period, with the recently established New Zealand Space Agency working swiftly to introduce a flexible, outcomes-based regime that would foster opportunities and manage risks.[8] This regime includes provisions for:

- A decision-making framework to facilitate the development of the New Zealand space sector.
- A risk-based and proportionate decision making approach that allows for flexibility to set conditions on a case-by-case basis.
- Future proofing to accommodate future technological changes.
- Signing the NZ-US Technology Safeguards Agreement, which affords protection to U.S. launch vehicles and spacecraft technology in relation to launch activities undertaken within New Zealand.[9]

Further initiatives undertaken by the New Zealand government to support the national aerospace sector include, but are not limited to:

- Establishing Catalyst: Strategic – Space 2019, a dedicated funding stream to support the development of space sector capability.
- Setting aside $2m in its annual budget for Land Information New Zealand to explore a joint Australia-New Zealand satellite-based augmentation system (SBAS) to improve the accuracy of regional GPS technology.[10]
- Introducing Civil Aviation Rules for unmanned aircraft, including UAS, remotely piloted aircraft systems (RPAS) and drones. These rules facilitated one of the most accommodating regulatory frameworks for unmanned aircraft innovation in the world.[11]

3.3 A global perspective on aerospace

The global aerospace environment has traditionally been characterised by concentrated capability among a small number of space-faring nations with strong militaries. As this capability has widened, consumer demand for aerospace-enabled technologies has also grown.

Globally there has been a shift away from exclusive military and defence applications to customer-centric, data-driven solutions delivered by a growing number of private sector companies. From launch service providers and satellite manufacturers to UAV companies, new entrants have begun to challenge traditional market leaders with innovative offerings at reduced cost. Indeed, the US Air Force recently reopened competition for the evolved expendable launch vehicle market by granting contracts to SpaceX, ULA, NGIS and Blue Origin; a testament to the growing role of private companies in the aerospace sector.[12]

USA is a world leader in aerospace, contributing over 50% of global revenues.[13] Home to Boeing, the world's largest aerospace company, Washington State possesses a thriving aerospace cluster with an extensive supply chain. This includes metal fabrication, precision plastics, assembly centres, machining, and energy systems.

The European commercial aerospace sector contributed just over 36% of global aerospace revenues in 2017.[14] In France, arguably the most dominant player in Europe, aerospace companies benefit from strong government support and an enduring mandate to grow the sector. The ASTech Paris

[8] Hutchison, K., MacNeill, K., Mumford, P., & Sim, V. (2017, November). Managing the Opportunities and Risks Associated with Disruptive Technologies: Space Law in New Zealand. Policy Quarterly, 13(4).
[9] The Government of New Zealand. (2016). Agreement between the Government of New Zealand and the Government of the United States of America on Technology Safeguards Associated with United States Participation in Space Launches from New Zealand. Wellington: The Government of New Zealand.
[10] Land Information New Zealand. (2019, August 12). Satellite-based augmentation system.
[11] Ministry of Transport. (2019, June 6). Drones.
[12] Soshkin, M. (2018). IBISWorld Industry Report: Space Vehicle & Missile Manufacturing in the US. IBISWorld.
[13] Deloitte. (2018). 2018 Global aerospace and defense industry financial performance study.
[14] Deloitte. (2018). 2018 Global aerospace and defense industry financial performance study.

Region aerospace and defence competitiveness cluster was established in 2007, and favours agile innovation through a strong network of small- to medium-sized companies. It receives support from a number of large corporations such as Airbus and Safran Group. ASTech comprises 331 members including 155 small- to medium-sized companies, 92 large corporations and 54 training and research facilities.[15]

Other countries, including Canada, Brazil, Japan, China, India, and Australia contribute around 11% of global aerospace revenues.[16] Most similar to Christchurch is Adelaide, whose main capabilities and expertise within aerospace exist in space enabling services, such as Earth Observation, satellite communications and space-based position, navigation and timing. Australia's Space Agency is also based in Adelaide, with 60 space-related organisations, and 800 people employed by the sector.[17] In contrast to New Zealand, South Australia's aerospace economy is largely anchored by the Australian Defence Force, and involves a range of surveillance, intelligence, and electronic warfare capabilities. The region hosts a range of large corporations, such as Airbus Group Australia Pacific, BAE Systems Australia, Boeing Defence Australia, Cobham Aviation Services, Lockheed Martin Australia, Nova Systems, QinetiQ, Raytheon Australia, RUAG Australia and TAE, along with a strong small- to medium-sized business network.[18]

[15] Notre Rapide. (2017). Paris Region: The Top French Aerospace Region.
[16] Deloitte. (2018). 2018 Global aerospace and defense industry financial performance study.
[17] The Guardian. (2018, December 11). Australia's new national space agency to be based in Adelaide.
[18] South Australia the Defence State. (2019). Aerospace Industry.

4 Why Christchurch?

Christchurch's strengths lie at the nexus of its competitive advantages, existing capabilities, and strong collaboration between tertiary institutes, Government, peak bodies, and private sector.

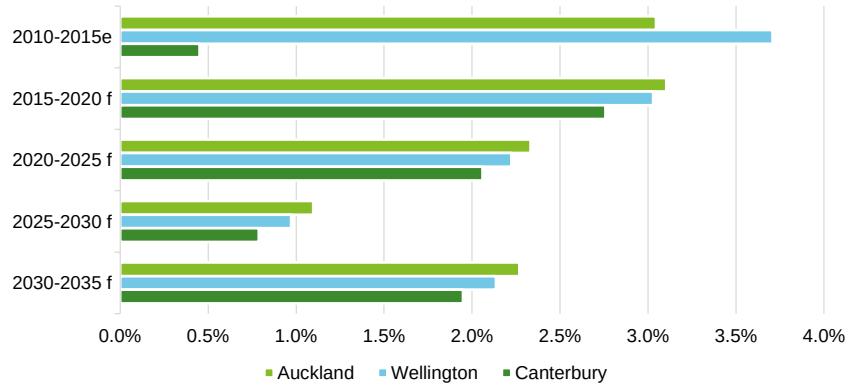
4.1 The Christchurch economy relative to other regions

Christchurch is the third largest urban area in New Zealand, and contributes close to 9% of national GDP.[19] However, Christchurch's economic growth for the past four years has been sluggish. In the four years to 2018, Canterbury's GDP grew at a 4-year average annual rate of 1.5%, compared to 4.3% for Auckland and 2.8% for Wellington.[20]

The post-rebuild slowdown in Christchurch has been a key contributor to weaker growth. Between March 2012 and March 2015, average annual economic growth in the city was 4.7%, reflecting the sizeable increase in construction activity during this period.[21] Naturally, as the rebuild nears completion, activity has begun to return to normal levels and has negatively affected economic growth.

Christchurch is also not immune to wider economic trends taking place at a national level. The New Zealand economy is continuing to soften, with slower population growth, weakening business confidence, and some sectors that lifted the economy at its peak in 2016 - construction and tourism - approaching capacity. However, the future outlook for Christchurch is somewhat brighter than recent historical performance suggests. Growth rates in Christchurch are expected to return to national averages, albeit at a slightly lower yearly rate than Auckland and Wellington. NZIER forecasts show economic growth in Christchurch will be 2.0% per annum between 2020 and 2025, compared to 2.3% and 2.2% in Auckland and Wellington, respectively (see Chart 4.1).

Chart 4.1 Regional forecasts of gross domestic product, 2010 to 2035 (% growth)



Source: NZIER Quarterly Predictions, Deloitte Access Economics Analysis

[19] Greater Christchurch Partnership. (2018). Gross Domestic Product (GDP).
[20] NZIER. (2019, June). Quarterly predictions: June 2019.
[21] Infometrics. (2017). Infometrics Regional Perspectives. Auckland: Infometrics.

4.2 Christchurch is well placed to offer and create opportunities for aerospace

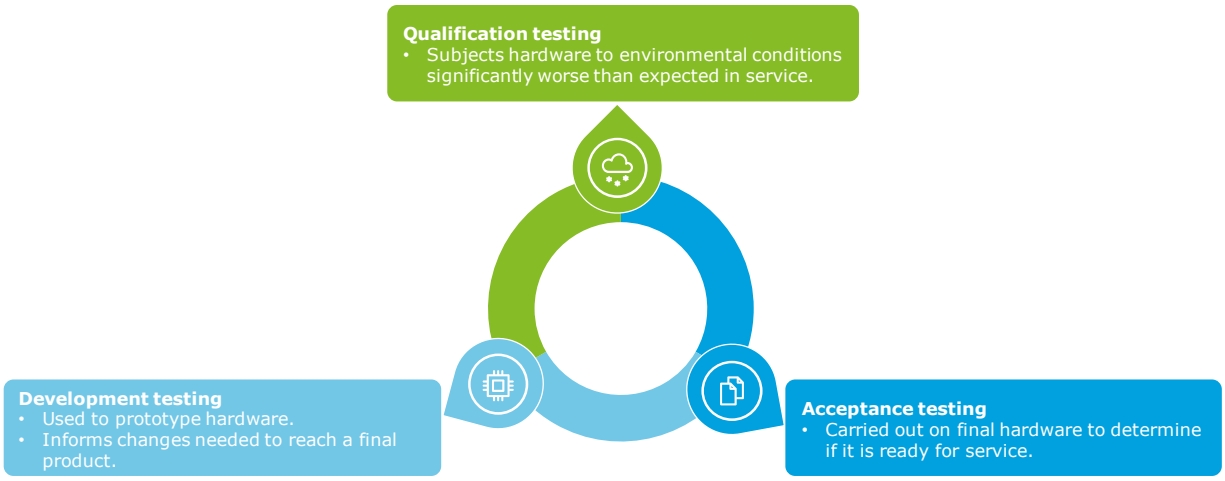
4.2.1 Current test-bed facilities give companies a head start on the global stage

Testing activities allow businesses to assess if their products are built appropriately for the environments they will see through their operating lives.

To perform the tests outlined in Figure 4.1, aerospace companies wishing to develop aerial vehicles, launch systems, satellites, and other hardware require two different kinds of commercial testing facilities:

- **Environmental tests:** allow companies to perform quality and assurance checks by applying stress to a potential product before it goes to market. This is particularly important to ensure that products perform the way they are supposed to over extended periods. These tests usually involve burn-ins, life-cycle tests, materials survivability, and extreme environment tests by replicating likely atmospheric conditions.[22]
- **Altitude tests:** usually involve testing the mechanical functionality of manned and unmanned vehicles, and hardware, during high-altitude flight scenarios.

Figure 4.1 Aerospace hardware testing stages



Source: IDS Consulting, Deloitte Access Economics

Christchurch offers a wide range of public and private environmental testing facilities. The University of Canterbury's capabilities include, but are not limited to: particle size analysis, reverberation labs, wind tunnels, aerodynamics labs, nanofabrication, corrosion testing, fatigue testing, hardness testing, impact testing, compression testing, and tensile testing. Local Christchurch company Holmes Solutions offers a range of services including, but not limited to wind load testing, destructive testing, seismic testing, product refinement, and product compliance. Other testing capabilities are also available through Ara Institute of Canterbury, Callaghan Innovation, and SGS New Zealand.[23]

Altitude testing facilities are generally situated in locations with vast swathes of uninhabited land, low air and sea traffic, and favourable atmospheric conditions. The remoteness of altitude testing facilities often introduces added costs, which make it more difficult for smaller companies to engage in prototyping.

Birdlings Flat, a renowned altitude testing facility is only a 45-minute drive from the Christchurch city centre, and was home to the University of Canterbury's Atmospheric Physics Group for a number of decades. The university operated its Stratosphere Troposphere, Medium Frequency, and AMOR Meteor radars there, and has conducted atmospheric soundings using rockets at the site.[24] The University of Canterbury also operates a 100 sq km UAV test range at Kaitorete Spit. This area of

[22] NASA. (2017, August 4). Altitude/Environmental/Space Testing Facilities.
[23] University of Auckland. (n.d.). NZ National Testing Facilities.
[24] Plank, G. (2008). Atmospheric Physics Group.

land is designated as a Restricted Area by the Civil Aviation Authority of New Zealand (CAA) and has a maximum ceiling of 1000 feet.

The physical qualities of both Birdlings Flat and Kaitorete Spit, and their proximity to a major city allows for incidental cost reduction and a faster iteration process.

4.2.2 Christchurch's physical attributes and access to critical infrastructure offer a point of differentiation for aerospace

Christchurch occupies an important strategic location within New Zealand. As one of the five international gateways to Antarctica and the only one in New Zealand, the city has a rich history of exploration, science, ecology, and climate change activities. The Antarctic region offers access to extreme environment testing grounds, which are used to assess advanced prototypes in the final stages of research and development. The University of Canterbury also operates Gateway Antarctica as its centre for national and international Antarctic research projects.

Excellent air infrastructure provided by Christchurch Airport, seaport infrastructure at Lyttelton, and proximity to various research bases, has seen Antarctic-related activities grow to an annual economic contribution of over $235 million.[25] With interest in the Antarctic as an extreme environment testing ground increasing among high-profile institutes such as NASA, Christchurch possesses a unique opportunity to becoming more involved in international aerospace initiatives.

Christchurch's low air traffic makes it an ideal city for the development and counter-seasonal testing of aerospace technologies, including sub-orbital rocket launch, drones and satellites. Low annual rainfall and cloud cover relative to the rest of the country also means that Christchurch has the ability to accommodate emerging technologies such as Free Space Optical Communication (FSO), which relies on favourable atmospheric conditions. [26] [27] Fewer geographical constraints than other urban centres - which are a key driver of commercial and residential rental costs - also means the city is well placed to expand, which large amounts of primary sector land available for testing activities.

4.2.3 Christchurch has a competitive advantage in manufacturing

Christchurch is home to a strong electronic manufacturing cluster, with 18% of the country's electronics and electrical manufacturing businesses and one third of the country's manufacturing employees.[28] Large anchor firms include Tait Communications, who employ over 650 people globally and export 95% of their products from Christchurch.

Relative to Auckland and Wellington, Christchurch's share of manufacturing compared to the national average is the highest from both a GDP and employment perspective (Table 4.1). This indicates that Christchurch has an existing competitive advantage in manufacturing relative to other regions across New Zealand.[29] Close proximity to strong manufacturing bases throughout the wider Canterbury region also allows efficient access to New Zealand's aerospace-adjacent value chains for international companies wishing to do business in Christchurch.

Table 4.1 Christchurch has a competitive advantage in manufacturing

Indicator	Christchurch	Wellington	Auckland
Sector share score (GDP) [a, b, 30]			
Manufacturing	1.10	0.77	0.99
Primary Manufacturing	1.02	0.97	0.84
Other Manufacturing	1.24	0.41	1.26

[25] Christchurch City Council. (2018). Christchurch's Antarctic Gateway Strategy.
[26] NIWA. (2000). New Zealand mean annual rainfall (mm), 1971-2000.
[27] Son, I. K., & Mao, S. (2017, May). A survey of free space optical networks. Digital Communications and Networks, 3(2).
[28] Ministry of Business, Innovation & Employment. (2018). Beyond commodities: Manufacturing into the future.
[29] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).
[30] Statistics New Zealand. (2018). Gross domestic product, by region and industry (Annual-Mar).

Sector share score (Employment) [a, b, 31]			
Manufacturing	1.15	0.51	0.96

Source: Statistics New Zealand, Deloitte Access Economics analysis
[a] Data only available for Canterbury region

4.2.4 A collaborative environment that breeds innovation

Christchurch has a highly connected and willing aerospace community, which is due in part to the city's small size. A strong network of space lawyers, space entrepreneurs, aerospace companies, and government organisations means there is a convergence of thinking that spans tertiary institutions, private sector companies, subject matter experts, entrepreneurs and investors.

Christchurch also has a demonstrated record of accomplishment in international aerospace initiatives. 2019 will mark the seventh year that NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) has run its winter stargazing mission from Christchurch, which is estimated add at least $5 million to the Christchurch economy per year.[32] The U.S. National Science Foundation's Antarctic Program also has a base at the Christchurch International Airport.

Strong private sector, government and tertiary linkages have supported the development of a number of key sector 'touch points', including the Christchurch Aerospace Centre, Kea Aerospace, and UC Aerospace Club. New Zealand's Aerospace Challenge, which aims to improve commercial outcomes and build Aerospace innovation ecosystems, is also held in Christchurch and sponsored by Airbus.

4.2.5 Low costs in Christchurch relative to other regions

Relatively low costs in Christchurch, relative to other regions in New Zealand, make it an attractive location for both start-ups and established companies.

Firms directly operating within the aerospace sector, as well as those on the periphery, face the same set of operational, production, and investment decisions as firms in other industries; however, the aerospace sector is usually characterised by extended timelines to profitability, rapidly changing technologies, and significant operational scale. That is, companies face large upfront costs with no guarantee of success. Furthermore, statistics from NYU Stern show that of 94 industries in the USA, the aerospace sector faces the 12th highest cost of goods sold to sales revenue ratio in the country, and falls within the mid-range of industries in terms of after-tax operating margins.[33]

One of the key advantages Christchurch offers to the sector is cost, as inputs in the form of the labour, materials, and components are generally cheaper in Christchurch compared to New Zealand's main economic centres. Commercial rental costs in Christchurch are around one third of those in Auckland's prime CBD areas.[34] Likewise, residential property costs are lower, with rates around 11% lower than Wellington and 28% lower than Auckland.[35] The cost of living more broadly has also remained relatively flat, with Canterbury's regional CPI growing at a 4-year CAGR of 0.8% between 2014 and 2018, compared to Wellington at 1% and Auckland at 1.3%. Residential rental costs, in particular, fell by 0.3% per year over the same period, compared to Wellington, where they rose by 5.2% per year, and Auckland, where they rose by 3.6% per year.[36]

[31] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).
[32] Email correspondence with ChristchurchNZ.
[33] Damodaran, A. (2019, January 1). Margins by Sector (US).
[34] Steeman, M. (2019, June 7). Big city retail and office rents are stable or falling, new report shows.
[35] New Zealand Taxpayers' Union. (2018). 2018 Ratepayers' Report.
[36] Statistics New Zealand. (2018). Infoshare tables: CPI Regional Groups (Broad Regions) (Qrtly-Mar/Jun/Sep/Dec).

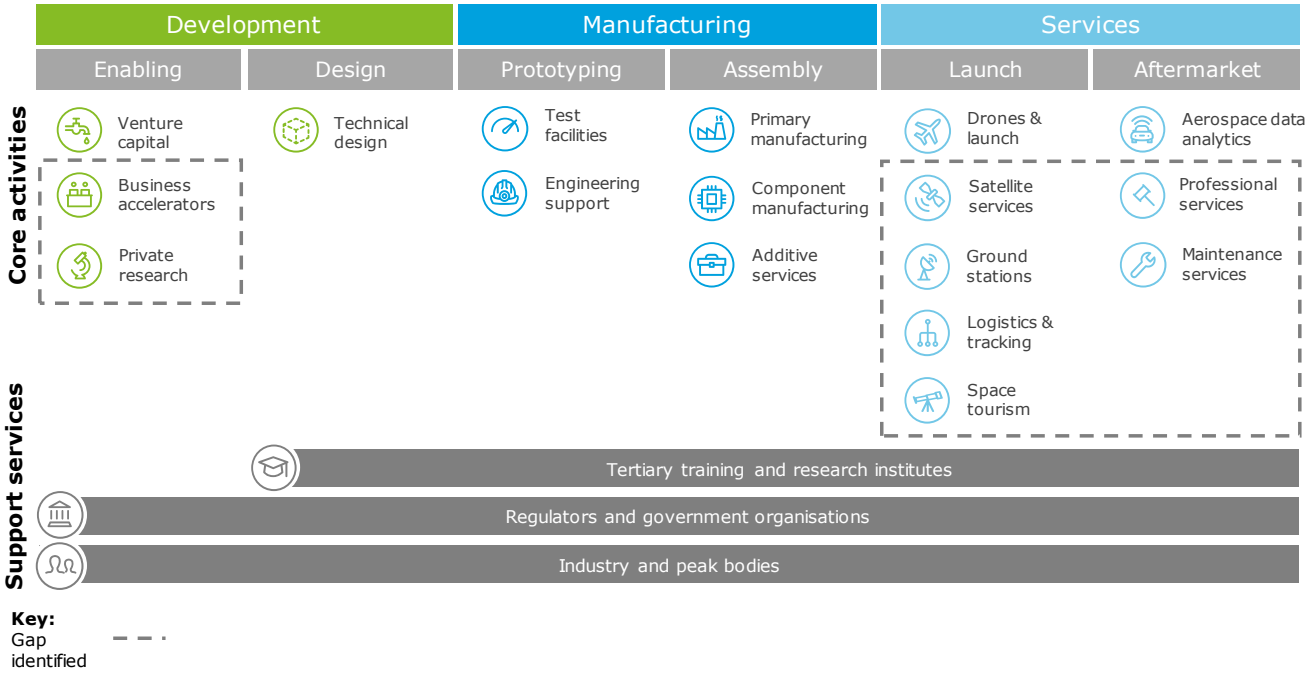
5 The Christchurch aerospace ecosystem

Pockets of aerospace excellence and deep capability have put Christchurch on the map.

The Christchurch aerospace sector can be thought of as an ecosystem spanning support, manufacturing and aftermarket services. Christchurch possesses a wealth of capability spread across a large number of firms whose core activities are not necessarily aerospace-related.

Based on stakeholder consultation and survey results, Deloitte has developed a representative value chain for Christchurch's aerospace sector. In the following section, we have also provided a non-exhaustive list containing a number of companies that either operate directly within aerospace, or have been identified as having the capability to do so in the future.

Figure 5.1 Christchurch aerospace sector ecosystem



Source: Deloitte Access Economics

5.2 Development

Early-stage support services play a vital role in Christchurch's aerospace start-up ecosystem. Enabling services primarily assist business with idea generation, market validation, go-to-market strategies, business planning, and scaling; whether that may be through seeking early-stage capital and government grants or growing one's customer base. In Christchurch, many of these programmes are funded by the government, and provide a range of facilities, workspaces and dedicated mentors to assist with commercialisation. While venture capital is an important part of the aerospace value chain, these companies are not constrained by geographic boundaries. In this sense, a lack of venture capital companies headquartered in Christchurch does not point to a lack of activity. For

example, Accel-KKR and Pencarrow Private Equity, while not Christchurch-based, jointly provided a growth equity investment in Seequent in late 2018.[37] A host of technical design services are also on offer in Christchurch. Capabilities range from mechatronic systems and 2D and 3D component design to user experience consulting.

We note that there is a capability gap in Christchurch for aerospace-specific incubation services, and bridging this gap has been identified as a key action point in this Sector Plan.

Table 5.2 Development service offerings in Christchurch

Value chain component	Examples
Enabling: Venture capital	Canterbury Angel Investors, Ngai Tahu Capital Limited, Powerhouse Ventures Limited
Enabling: Business accelerators	New Zealand Aerospace Challenge Incubator Programme, ThincLab, Startup Christchurch, Ministry of Awesome, Te Ohaka, Xstart
Design: Technical design	DESIGNsense Limited, Tinka Design Limited, inFact Limited, SAGE Designs Limited, Motovated Design and Analysis Limited, Engineering Design Consultants Limited, Calibre Design Limited

Source: Deloitte Access Economics

5.3 Manufacturing

Christchurch's aerospace manufacturing capability is among the strongest in the country. A range of testing facilities are available through both the University of Canterbury and privately owned companies, and specialised companies offer assistance with prototyping. Christchurch is also home to a strong base of fabrication companies, electrical manufacturers, precision manufacturers, metal finishers, and plastics specialists, which lends plenty of upside to a growing aerospace sector; particularly with respect to satellite or launch services, which are hardware intensive.

Table 5.3 Manufacturing service offerings in Christchurch

Value chain component	Examples
Prototyping: Test facilities	University of Canterbury, Holmes Group Limited, Callaghan Innovation, Ara Institute of Canterbury, inFact Limited, Contour Engineering Limited, Contex Engineers Limited, Pacific Simulators
Prototyping: Engineering support	Caliber Design Limited, Thelning Design Innovation Limited, SAGE Designs Limited, Motovated Design and Analysis Limited, IDS Consulting Limited, inFact Limited, Swann Intelligence, Design Energy Limited, Contour Engineering Limited, Contex Engineers Limited
Assembly: Primary manufacturing	Pioneer Sheetmetals Limited, Hi-Tech Sheetmetals, ProMetal Industries Limited
Assembly: Component manufacturing	Davin Industries Limited, ENI Engineering Limited, Mach3 Industries Limited, Pacific Simulators Limited
Assembly: Additive services	Tait Communications Limited*, Fabrum Solutions Limited*, South Island Component Centre Limited, QuickCircuit Limited, GPC Electronics (New Zealand) Limited, Shamrock Industries Limited*, Tatom Engineering (2014) Limited, Contour Engineering Limited*, Track Industries Limited, Texco Holdings Limited, Contex Engineers Limited, Allied Telesis Labs Limited, Enatel*, TE Connectivity Limited*,Raztec Limited, DesignA Electronics Limited, Electric Power Engineering Centre

Source: Deloitte Access Economics

* Aerospace-specific manufacturer

[37] Pencarrow Private Equity. (2018, September). Seequent announces growth equity investment with Accel-KKR.

5.4 Services

In the downstream segment, Christchurch has experienced strong growth in 'new aerospace'. While no satellites have been launched or are currently controlled from Christchurch, demand for satellite services is growing rapidly, driven by a hunger for data-informed insights and internet of things (IoT) technologies.[38] With a particular focus on Earth Observation for pasture management, a number of companies have emerged to transform aerospace data into commercially attractive products. This includes drone companies, drone surveyors, apiculturists, geographic information service providers, and geolocation services for fleet tracking. As the aerospace sector in Christchurch begins to mature, existing professional services will begin to expand their offering to accommodate aerospace clients. A good example of this is the growing demand for aerospace lawyers and aerospace-related insurance coverage.

While space tourism is captured under this segment of the aerospace value chain, it is unlikely to become a feasible opportunity for Christchurch over the next five years. Therefore, space tourism is not considered further in this report.

Table 5.4 Service offerings in Christchurch

Value chain component	Examples
Launch: Satellite services	KiwiSat, Dawn Aerospace Limited
Launch: Drones & launch	Skybase Limited, Global Aerial Platforms Limited, DroneScape Limited, New Zealand Forest Research Institute Limited (Scion), Helicam Pro, Zephyr (KittyHawk), Pyka Inc., Dawn Aerospace Limited
Aftermarket: Aerospace data applications	Seequent Holdings Limited, Precision Tracking Limited, Abley Limited, WeRdatascience, Orbica Limited, Opus International Consultants, Traverse Services Limited, Livestock Improvement Corporation Limited, DataGenius Software Labs Limited, Hivemind Limited, Trimble Navigation New Zealand Limited, Airways
Aftermarket: Professional services	Parryfield Lawyers Limited, Gravity Lawyers Limited (Dr. Maria Pozza)

Source: Deloitte Access Economics

5.5 Support services

Christchurch has the University of Canterbury and Ara Institute of Canterbury to provide graduates, aerospace-related skills and knowledge to the sector; however, the University of Canterbury tends to attract more students for aerospace-related disciplines. Indeed, the University of Canterbury has the opportunity to leverage its globally ranked position in civil engineering and geography to strengthen its eminence in aerospace.[39] A number of industry bodies also exist in Christchurch. Their activities include promoting the sector and organising participants to form a cohesive aerospace offering.

Table 5.5 Support offerings in Christchurch

Value chain component	Examples
Tertiary training and research institutes	Ara Institute of Canterbury, University of Canterbury, The Geospatial Research Institute (UC)
Regulators and government organisations	MBIE, NZTE, ChristchurchNZ, Land Information New Zealand
Industry and peak bodies	Kea Aerospace, SpaceBase, Christchurch Aerospace Centre, Canterbury Tech Christchurch Engine Centre

Source: Deloitte Access Economics

[38] ChristchurchNZ, ThinkNew, New Zealand Education. (2019). Supernode: Aerospace and Future Transport.
[39] QS World University Rankings. (2019). Engineering and Technology.

We acknowledge that Christchurch also has deep aerospace expertise on an individual basis:

- Dr Chris Hann, University of Canterbury: Rocketry and GNS
- Kelvin Barnsdale, University of Canterbury: Drone testing
- Alan McInnes, University of Canterbury: Robotics
- Miranda Satterthwaite: NASA Education, deep knowledge of aerospace and Antarctica
- Dr Phillip Sueltrop: Rocket guidance navigation
- Rafael Kargren: previously involved with the Swedish National Space Agency
- Andrew McNamara: UK aeronautical engineering expertise
- Eric Dahlstrom and Emeline Paat-Dahlstrom: Global space entrepreneurs
- Dr Sarah Kessans: Synthetic biology and NASA links

6 Key enabling factors for Christchurch aerospace

Fostering a vibrant aerospace sector is not something that can be achieved overnight. To become, and remain, competitive on both a national and global scale requires deep expertise supported by significant capability building investments.

Our stakeholder consultations revealed three recurring themes central to Christchurch's future aerospace growth plan:

Strengthening capability and workforce to ensure that the aerospace sector is positioned for growth.

Creating a business environment to attract new business and encouraging existing businesses to expand into the aerospace sector.

Experimenting through niche expertise and innovation.

6.1 Strengthening capability and workforce

Christchurch has expertise in almost every segment of the aerospace sector, particularly in niche areas such as advanced manufacturing. However, there exists capacity for growth to attract and retain the right skills to Christchurch. New Zealand has traditionally faced a shortage of graduates from STEM fields, which has begun to negatively impact businesses operating in technical environments.[40] There is also a shortage of engineers qualified and trained to participate in the aerospace sector. Other common occupations in aerospace include professional, scientific, and technical services, software developers and programmers.

Stakeholder consultations reveal that attracting and retaining the appropriate skills is more important than growing a city's population. Indeed, if Christchurch intends to become a vibrant aerospace hub, it must convince those with the skills and capabilities relevant to the sector to migrate there. However, these skills will not just be limited to traditional engineering and scientific fields. The pace of technological change within the sector means that technical skills have a short shelf life; a commitment to 'lifetime learning' will be critical to maintaining a strong aerospace workforce.[41]

The likely factors to consider in attracting the right skills for Christchurch's aerospace sector include:

[40] Forbes, S. (2019, May). Immigration Minister Iain Lees-Galloway outlines immigration changes to address labour market skills shortages with focus on the regions and teachers.
[41] Deming, D. J., & Noray, K. (2018). STEM Careers and the Changing Skill Requirements of Work. NBER Working Paper No. 25065.

6.1.1 Creating job opportunities in light of changing skillsets

The most important factor in attracting the right skills is the availability of jobs in the aerospace sector. If the right job opportunities are available in Christchurch, and they provide both the appropriate financial and non-financial incentives, they are more likely to attract the right skills to Christchurch.

Labour costs, particularly for small companies, are a significant component of aggregate business expenditure, so in order for Christchurch to remain competitive, companies must be confident in the level of technical expertise available. An attractive workforce will therefore be sufficiently skilled, affordable, and highly agile to adapt to fast-changing skillsets needed in the sector. Christchurch will also need to be aware of global megatrends and consider how it can supply a steady stream of talent to companies within the sector.

6.1.2 Lifestyle attraction

Choosing a career is a difficult decision, and for many graduates in New Zealand, this will involve an assessment of the relative potential lifetime earnings, job satisfaction, and promotion opportunities. Christchurch will also need to compete for technical expertise with New Zealand's larger economic centres.

Christchurch's identity as a city is underpinned by three themes: Old English heritage, the 'Garden City', and sport.[42] More recently, visitors have also become increasingly interested in Christchurch's environmental and economic sustainability profile.[43] Therefore, the attractiveness of Christchurch as a city, including its living standards and broader cost of living, education quality, consumer choice, and other economic opportunities will play into future workforce capability.

6.1.3 Aging workforce

Christchurch's population also has an average age of well above the national average and, like many of New Zealand's cities and towns, Christchurch possesses an ageing workforce too. In fact, Christchurch and Canterbury require an additional 70,000 additional workers over the next 15 years to fill vacant positions.[44] Employment shortages necessarily constrain wider business growth, so the region must ensure that educational resources are directed to projected skill shortage areas.

6.2 Creating a business environment to attract new and expanding business

Christchurch has at least one player within most levels of the aerospace supply chain, but there is significant room for capability to deepen. This growth may be facilitated by attracting new businesses to the city or encouraging existing businesses to transition to aerospace-related offerings.

6.2.1 Business attraction

Firms in the aerospace sector are likely to face significant set-up costs, capital requirements, and a long time to profitability. The decision to locate to Christchurch will therefore be a function of the relative benefits available in the form of cost savings and access to supporting infrastructure and the wider supply chain.

Businesses locating to Christchurch will need to be confident that local regulations are not overly cumbersome or prohibitive to their business activities. Regional bylaws, particularly with respect to resource management, land zoning, and earthquake strengthening, may act as push or pull factors.

In order to encourage smaller businesses to locate to Christchurch, the quality and depth of information available will be important. Stakeholders should ensure that information on the Christchurch aerospace sector is easily accessible to organisations wishing to enter the sector, and at a level of communication suitable for various organisational maturities.

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[42] ChristchurchNZ. (2016). Christchurch Visitor Strategy - Setting the Direction 2016. Christchurch: ChristchurchNZ.
[43] UC Business School and ChristchurchNZ. (2018). International Visitors' Perceptions of Sustainability in New Zealand and the Canterbury Region: Insights from UGC and IVS. Christchurch: University of Canterbury.
[44] ChristchurchNZ. (2018). Christchurch Prosperity Framework: 2018-2028. Christchurch: ChristchurchNZ.

Steep cost curves and technical knowledge barriers (patented technologies) that require substantial investments in research and development increase the likelihood of failure for firms undertaking business transition activities. A lack of connected capital available for early-stage start-ups in New Zealand – for example, companies operating in 'juvenile' but saturated areas like drone technology – increases the risk that Christchurch aerospace companies are constrained in their ability to scale and access key export markets.

6.2.2 Business transition

Awareness of the capabilities required and those currently on offer within Christchurch will drive long-term business transition in the City. For example, aerospace suppliers have to rely on large contracts for extended periods, with very specific requirements and intensely regulated processes and quality-testing procedures. Developing this awareness will assist businesses in identifying which part of the sector they could potentially service, the minimum viable change needed in order to transition, and/or how they could adjust their product offering to suit aerospace clients.

A software developer, for example, could just as easily service the aerospace sector as it could the financial services sector. Hence, the decision to transition to aerospace-related business activities will be determined by the relative accessibility of capital, the existence of sector support networks, information transparency, and the depth of skills available in the labour market.

We recognise that the manufacturing sector is currently growing less than CPI, and MBIE has a strategy focused on Industry Transformation Plans. Aerospace offers this opportunity to transform the current manufacturing capability in Christchurch to aerospace.

6.2.3 Aerospace technology adoption

Precision agriculture is just one potential application of aerospace data, but the willingness of downstream business to adopt such technology may act as a barrier. Indeed, the primary barrier to using precision farming is often the cost, followed by uncertainty surrounding its benefits and continuously evolving technology. Other barriers may include the need for training and user-friendliness. Full end-to-end support could help overcome these issues.

In the longer term, providers of aerospace technology will almost certainly overcome these challenges. For example, new markets for sustainable technologies are already emerging as resource constraints and climate change risks increase.

6.3 Experimenting through niche expertise and innovation

6.3.1 Innovation and research and development

Home to NZi3 and HITLab, Ara Institute of Canterbury, and Eaton's R&D unit, Christchurch has deep and diverse invention capabilities.

Two examples of how research and development is encouraged in New Zealand include:

- An R&D tax credit of 15% for eligible spend
- The New Zealand government's business innovation agency - Callaghan Innovation – has committed over $216m to R&D grants and co-funding up to 40% of companies' R&D expenditure, in the year to June 2018.[45]

Statistics New Zealand figures for 2018 show that manufacturing – a competitive advantage for Christchurch - was the most common use of R&D expenditure in New Zealand, absorbing 17% of the national spend.[46] In terms of its innovative outputs, Christchurch is the second highest in the country, behind only Wellington, producing an average of 132 patent applications per year between

[45] Ministry of Business, Innovation & Employment. (2017). The Investor's Guide to the New Zealand Technology Sector.
[46] Statistics New Zealand. (2018). Research and development survey: 2018.

2014 and 2018.[47] This is despite a far lower aggregate R&D investment value, and fewer large businesses.[48]

On a global basis, targeted R&D tax credits are frequently used to accommodate the aerospace sector. For example, Seattle has a range of state R&D tax incentives designed to make the city attractive to aerospace-related companies. This includes tax credits for pre-production development, and reduced business and occupation rates for aerospace companies more generally.[49] However, evidence on whether R&D tax incentives have net positive welfare effects is mixed.[50]

6.3.2 Test-bed facilities a critical success for the aerospace sector

Our consultations revealed that one of the greatest opportunities to grow the Christchurch aerospace sector is ensuring that the city has strong test-bed facilities.

Large international companies often have a view to speed up the product development cycle, and Christchurch has a particular advantage relative to main cities in other countries:

- Christchurch is counter-seasonal to North America and Europe, which allows for product testing in winter environments (e.g., Southern Hemisphere Testing Ground).
- New Zealand's time zone also allows for co-location and outsourcing for 24/7 business operations.
- Christchurch has clear skies and prime launch potential for low-Earth orbit satellites.

6.3.3 Key challenges

While Christchurch is well placed to deliver strong commercial outcomes from aerospace innovation, the city must be prepared to address challenges around private funding constraints and intellectual property ownership.

- **Access to resources are required for commercial trails.** Due to limited or non-existent income streams, early-stage companies involved in prototyping rarely have the resources to engage in commercial trials. Venture capital/angel equity investments, government grants, and industry partnerships usually fill this gap. Groups like The Flying Kiwi Angels, Enterprise Angels, Ice Angels and the Canterbury Angels are all supporting local start-ups. However, with many competitors and a limited grant pool, not every company will qualify for funding. The size and scope of grants on offer will determine the level of innovation in early-stage companies.
- **Management of intellectual property.** A key challenge in implementing these test-bed recommendations concerns the ownership of intellectual property (IP). Clear and mutual understanding of IP ownership from project inception is imperative. Failing to do so may result in disagreements later on, which has an adverse impact on the research being undertaken. It is unclear from the information available how, and at what stage of the collaboration, IP rights are agreed in a New Zealand context. Guidelines on IP management could provide more transparency around this for universities and private companies.

[47] New Zealand Intellectual Property Office. (2019, August). Official Information Act request.
[48] ChristchurchNZ. (n.d.). Innovation in Canterbury. Christchurch: ChristchurchNZ.
[49] Department of Revenue Washington State. (n.d.). Incentive programs.
[50] Seattle Times. (2018, September 26). Boeing saved $227M from state tax incentives last year while it cut 6,000 jobs.

7 Goals and actions

7.1 Approach to identifying goals and actions

The Study Group identified key priority areas for Christchurch aerospace through sector workshops with a number of key sector participants. A key outcome of this work was to co-design a solution for the Christchurch aerospace sector that builds on local competitive advantage.

In the stakeholder workshops and interviews, we asked the following set of strategic questions:

1. What are your aspirations for Christchurch's aerospace sector?
2. Where will we play in order to best utilise our strengths?
3. Which actions are required to win in our competitive domain?
4. Which capabilities do we require?
5. What infrastructure and support do we need?

The following questions were also considered:

- What are others doing in New Zealand and globally?
- What has the role of government and private enterprise been in the journey?
- Which risks and opportunities have emerged based on recent market developments?
- What are the competitive and/or comparative advantages applicable to Christchurch, and which of them could be leveraged to achieve our goals?
- How would our suggestions sit in the wider current policy environment in New Zealand?

The Study Team has consulted the core Steering Group and incorporated their feedback in developing the goals and action points described in this chapter and the output of the workshop is summerised in **Appendix B** of this report.

The provided action points, in particular, will inform Christchurch's aerospace Sector Plan to 2025. We have categorised action points as quick wins (achievable within 6-12 months) and longer-term action points (achievable within 1-5 years).

7.2 Christchurch's aerospace sector vision

Christchurch's vision is to be **New Zealand's aerospace hub by 2025, with the city being home to a network of successful aerospace companies employing hundreds of people across the city**.

The ability to successfully implement the actions outlined in this chapter, and to achieve the desired depth and scale, requires a clear mandate by stakeholders to grow the sector and accommodate new businesses. This means reaching consensus with Iwi, Government, the tertiary sector and private sector, and a clear pathway to doing so will be to communicate the importance of a vibrant aerospace sector to the Christchurch economy. For this reason, we also have also provided an indication of which organisation we believe would be best suited to assume responsibility for each action plan.

7.3 Knowledge sharing

Goal #1

Establish an Advisory Industry Group to facilitate information sharing, and to link together upstream and downstream aerospace technologies in a coherent way to assist with market validation, demand determination and giving a clear line of sight to potential entrants.

There is currently a gap in the sector around knowledge sharing within the sector, across regions within New Zealand, and internationally. The establishment of an Aerospace Advisory Group to assume the responsibility of sharing knowledge across New Zealand could fill this gap.

An Aerospace Advisory Group is needed to implement some, if not all, of the initiatives outlined in this report. Similar to New Zealand Wine Growers, New Zealand Petfood Manufacturers Association, or the Space Association of Australia, the Aerospace Advisory Group could be comprised of at least 30 organisations, and charged with performing the following activities:

- Promoting and advancing the interests of the New Zealand aerospace sector in New Zealand and abroad
- Developing and overseeing aerospace sector strategies
- Facilitating knowledge sharing through the organisation of regular events and conferences
- Publishing sector research
- Lobbying the New Zealand government, where appropriate.

Additional responsibilities may include governance and member conduct, benchmarking, and monitoring of sector-wide performance.

The stakeholder workshops and interviews identified three action points relevant to this goal:

	Action items	Key stakeholders
1	**Quick win** Develop a capability directory to map the Christchurch aerospace value chain, from precision manufacturers and engineers to authorised resellers of satellite data.	Aerospace Advisory Group
2	**Quick win** Creating local and international awareness of aerospace in Christchurch to assist in prioritising this sector.	MBIE, ChristchurchNZ and local Iwi
3	**Long-term** Establish an open source space data platform, or 'data cube', to enable data-centric entrepreneurship and AI research.	MBIE, ChristchurchNZ

7.3.1 Capability directory

A holistic approach is needed in Christchurch to unlock the benefits of a robust aerospace ecosystem. A key risk, particularly with respect to microsatellite launch activities in Christchurch, is the potential for a supply-demand mismatch between aerospace data and downstream business applications. Indeed, hardware is not launched into orbit to collect data, but rather to answer questions.

In this sense, a key challenge for Christchurch will lie in improving end-user understanding as to the full extent of possibilities that aerospace enabled services can provide. This will connect data to purpose and commercial outcomes. For example, drones have recently been deployed across New Zealand as part of a 3-year study into the quality of the country's waterways,[51] and multiple companies have begun to offer satellite based remote sensing as a cost-effective technique for assessing water quality abroad.[52]

One way to increase transparency and support demand determination will be to establish an aerospace vendor database similar to Australia's capability directory.[53] This database would be publicly accessible and present the following information on Christchurch-based aerospace companies and test-bed facilities:

- Company overviews
- The position vendors occupy in the Christchurch aerospace value chain
- Certification and accreditations (e.g. authorised reseller of Airbus data, CAA design accreditation, etc.)
- Core business focus and adjacent capabilities
- Location and contact information

7.3.2 Creating local and international awareness

Creating international awareness of aerospace opportunities available in Christchurch will assist with prioritising resources from a local and central government perspective. One way of achieving this is through regional development activities, possibly in the form of joint Australia/New Zealand offerings to investors or delegation visits to aerospace hubs overseas.

Similar to New Zealand Story, stakeholders must communicate examples of Christchurch aerospace excellence with the world and engage in "why Christchurch" storytelling, including factors concerning IP protection, data integrity, regulation, and business friendliness. This may include weaving stories from Ed Hilary, Ernest Shackleton to modern Antarctic programmes.

7.3.3 Establish an open source data platform

The potential for mismatch between data collection activities and downstream business applications means that steps should be taken now to ensure aerospace data is accessible, reliable, and useful. Furthermore, Christchurch aerospace companies will require new strategies to stay ahead of emerging global competitors.

Establishing an open source GIS and EO data platform, or 'Data Cube', will serve as another avenue for innovation by allowing companies to exploit established infrastructure and analyse large quantities of ready-to-use aerospace data. Examples of successful Data Cubes include the Australian Geoscience Data Cube and Google Earth Engine, which have vastly reduced the time needed to process imaging data.[54]

7.4 Innovation and test-bed facilities

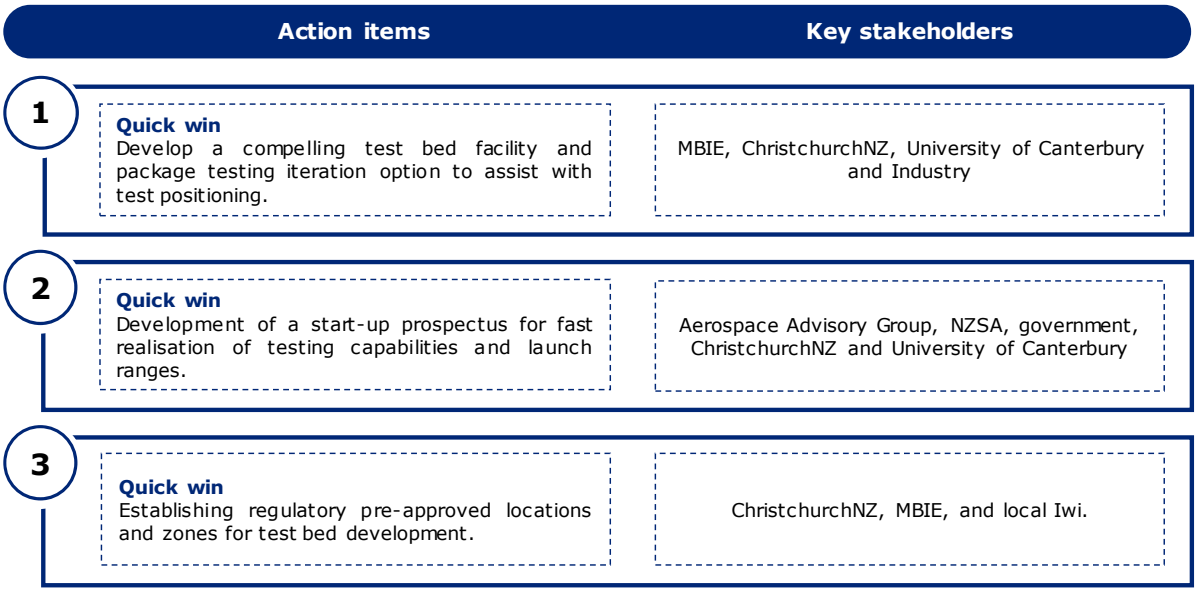
Goal #1

Develop world-class test bed capabilities to become a one stop shop for launch, mission control, and monitoring.

While Christchurch has existing test capabilities, stakeholder consultations tend to suggest that this is not located in a single place and knowledge is neither available, nor shared, with start-ups and

[51] New Zealand Herald. (2019, March 7). Drones to monitor NZ lakes.
[52] DHI Gras. (n.d.). Water quality monitoring from space.
[53] Aviation/Aerospace Australia. (2014). Australian Aerospace Industry Capability Directory.
[54] Salm, K. (n.d.). Open Data Cube: An Open Data Cube for NZ. Melbourne: FrontierSI.

established companies. This makes it difficult for new aerospace businesses to identify testing applications and acquire access to the testing facilities they require in a timely and cost efficient manner. In line with this goal, the following three action items have been identified:



Ways to strengthen Christchurch's innovation and test-bed capabilities include:

7.4.1 Establishing a world recognised testing facility in Christchurch

Establishing full-service environmental testing facilities in Christchurch and offering designated land sites for small- to medium-scale aerial testing has the ability to support local aerospace start-ups commercialise their ideas and attract international businesses. This is particularly true for satellites under 1,000kg and UAV/BVLOS technologies. Funding for such testing facilities is likely to come in the form of government grants (e.g. MBIE's Strategic Science Investment Fund) and/or joint ventures with private companies. Assistance with securing land for a dedicated environmental testing facility could be sought from NZTE.

The University of Canterbury has a range of environmental testing facilities, a UAV testing facility at Kaitorete Spit, and strong aerospace and rocketry expertise. Leveraging existing facilities on-campus could serve as a low-cost alternative to establishing an entirely new testing facility and would complement the University's intended aerospace engineering course offering. However, an entirely new testing facility must provide access to the following equipment to enable environmental testing of space hardware:[55]

- A thermal cycling chamber
- A vibration table for sine sweeps and random vibration tests
- A shock test rig
- A thermal vacuum chamber

Concerns with respect to IP protection should also be considered. If Christchurch intends to establish shared testing facilities based on a pay-per-use model, they should be equipped with the necessary security measures to safeguard the privacy of company product development. Anecdotal evidence from New Zealand aerospace experts suggests that university-based testing operations in Australia hire a number of legally independent technicians onsite who are bound by non-disclosure agreements.

[55] Correspondence with IDS Consulting

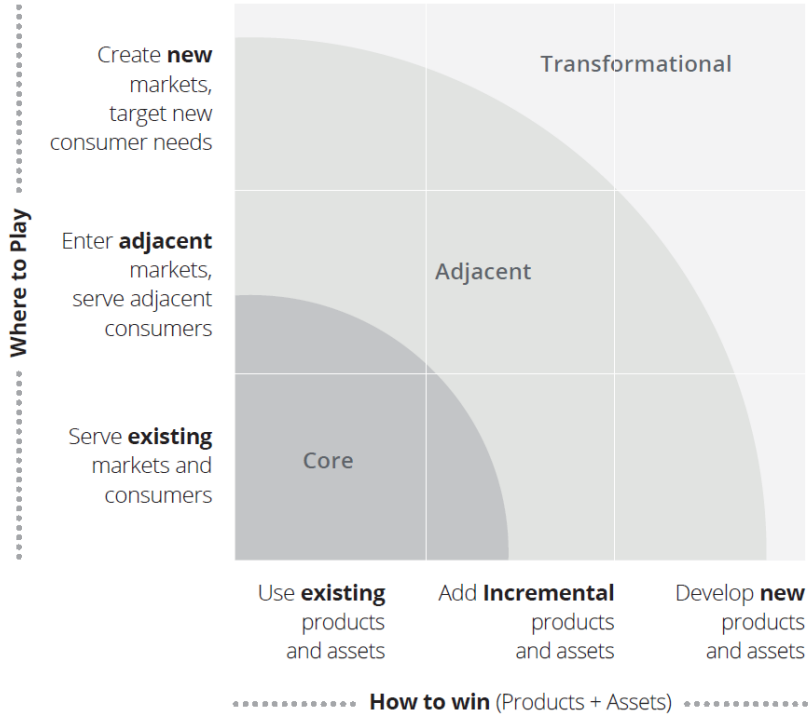
7.4.2 Identification of demand to inform innovation

A quick win is to develop this matrix for aerospace in Christchurch. There is currently a good understanding of the existing, incremental, and new products but a lack in existing, adjacent, and new markets and consumer needs over the next five years. This gap should be addressed as part of the implementation of the Sector Plan. This will also encourage active identification of demand for the aerospace sector.

We consider that innovation sits across 3 key levels:

- **Core innovation ambition** draws on assets that the company/sector already has in place, and are directed mainly toward existing services and markets. They may include innovations that, fundamentally, are about reducing overall costs or maintaining revenues.
- **Adjacent innovation ambition** takes something that the company/sector does well and pushes it into a new space. This is a more complex innovation designed to drive new growth – by serving new markets with existing capabilities and assets, or reinvigorating existing markets by using existing capabilities and assets in different and unique ways.
- **Transformational innovation ambition** involves pursuing new markets and/or new capabilities and assets, as well as delivering new business models, platforms, capabilities and consumer experiences. Such innovation uses its power to transform markets, disrupt competitors, and radically evolve perceptions of who the company competes with.

Figure 7.1 Critical lens framework



Source: Deloitte Access Economics

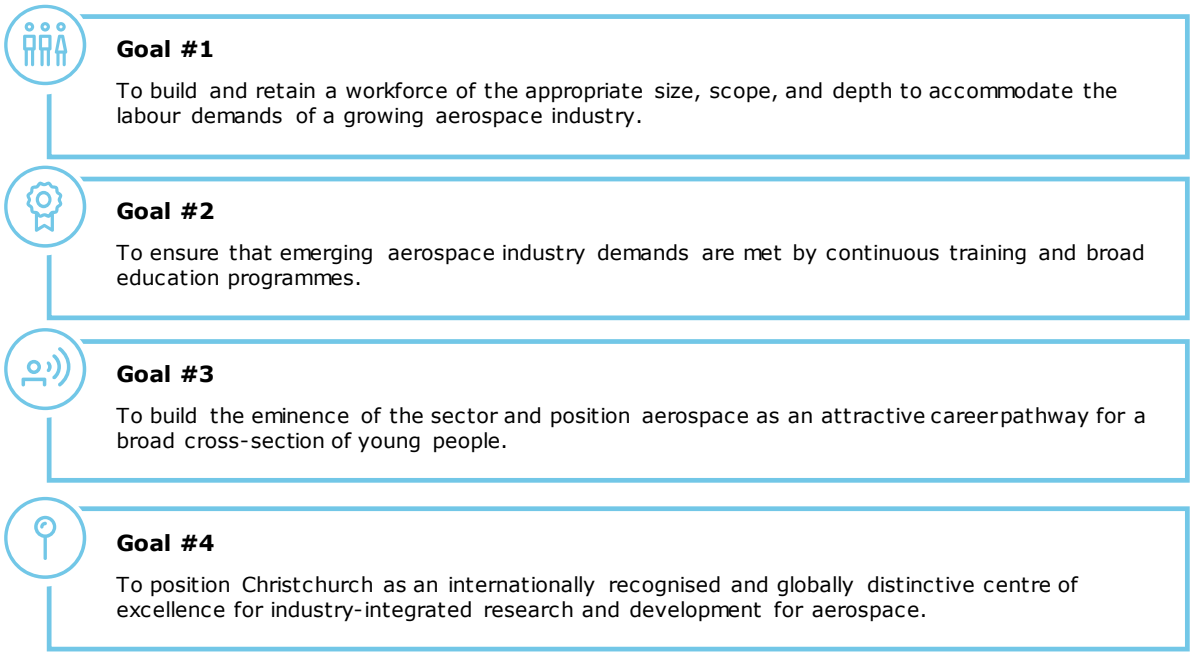
7.4.3 Supporting actions to facilitate information sharing

In line with these recommendations is a need for better quality information as to the opportunities available for aerospace start-ups in Christchurch. Developing a prospectus for start-ups with information on regional testing capabilities, their relevant applications, and value proposition will be paramount in ensuring that start-ups no longer have to 'reinvent the wheel' when launching innovative ideas.

Establishing regulatory pre-approved aerial testing locations will require alignment with local Iwi. As Iwi begin to pivot to technology focused sectors and tourism, they are also likely to become key

stakeholders in the aerospace sector. As such, ChristchurchNZ may wish to organise a series of workshops to introduce local Iwi to aerospace, which includes establishing which lands are available for test-bed facilities and how they can be utilised to benefit local companies.

7.5 Education and training



Christchurch has a number of existing initiatives in place to raise the profile and attractiveness of the aerospace sector as a career pathway. However, local aerospace organisations and government institutions have a number of additional opportunities to incentivise students and reduce skills shortage through seamless pathways from study to employment, or through scholarships and internship opportunities. Aerospace businesses would thereby benefit from a resilient aerospace workforce with strong knowledge of international markets, commercialisation, and patenting.

The key action points that emerged from our stakeholder workshops and interviews include:

	Action items	Key stakeholders
1	**Quick win** Investigate the establishment of a Space Research Centre to provide R&D focus and expertise, as well as participating in key space events and conferences.	University of Canterbury
2	**Quick win** Identify and develop 'cornerstone projects' supported by both government and industry designed to encourage commercialisation in operational environments.	MBIE
3	**Quick win** Establish undergraduate and postgraduate programmes to support both aerospace or aeronautical engineering and aerospace science.	University of Canterbury
4	**Quick win** Continue to strengthen the relationship between industry and the tertiary sector by establishing aerospace internships and work experience programmes.	ChristchurchNZ, Industry, University of Canterbury
5	**Quick win** Establish a regional fees-free and/or scholarship programme for young students wishing to pursue a career in aerospace, with pro-active support for diversity.	MBIE, Christchurch City Council

	Action items	Key stakeholders
6	**Long-term** Assess the demand for skills required now and in the future, and assess which training programmes are needed to ensure a robust talent pipeline.	ChristchurchNZ, Ara Institute of Canterbury
7	**Long-term** Continue to drive perception change from the bottom-up by actively promoting and funding Aerospace education programmes in schools.	MBIE, ChristchurchNZ, aerospace industry body

7.5.1 Workforce flexibility

Recent research demonstrates that due to the fast pace of technological change in many industries, the economic return to applied STEM degrees declines substantially in the first decade of working life.[56] Furthermore, countries with a strong focus on apprenticeships and vocational training tend to

[56] Deming, D. J., & Noray, K. (2018). STEM Careers and the Changing Skill Requirements of Work. NBER Working Paper No. 25065.

have lower youth unemployment rates at labour market entry, but there exists a significant trade-off between specialist and generalist education later in life.[57] One-way to future-proof Christchurch's workforce and insure against obsolescence of technology-specific skills will be to offer a series of micro-credential programmes alongside the University of Canterbury's proposed aeronautical engineering programme. This will allow a lower point of entry for interested students wishing to access knowledge and skills at low cost, while also ensuring that current aerospace workers can commit to lifetime learning initiatives in a time-efficient way.

Local government agencies and private sector participants may wish to examine aerospace-specific, structured overseas workplace programmes, which allow young people to gain experience in business innovation and commercialisation, as opposed to just gaining purely technically skills. Establishing a Space Research Institute at the University of Canterbury will be critical to implementing these initiatives, connecting private sector with academia by providing ground-breaking research to the University's commercialisation arms and providing a platform for students to gain business experience.

7.5.2 Workforce attractiveness

Christchurch's abundance of youth initiatives, such as the Cashmere High School Satellite Team who aspire to launch a CubeSat aboard a Rocket Lab spacecraft and Fabriko's Mission to Mars programme, point to an inspired future workforce.[58] [59] However, more could be done to communicate the opportunities associated with a career in the Christchurch aerospace sector. Potential initiatives include hosting an international, student-oriented aerospace conference in Christchurch or allocating additional funding to primary school-based aerospace education initiatives.

7.5.3 Supporting actions

Gaining a deeper understanding of the global aerospace sector and key factors influencing future workforce capability will ensure that the sector can adequately plan for the long-term. Funding research on megatrends affecting the aerospace sector and potential applications of aerospace technology to adjacent sectors will also raise the profile of the sector, while conducting a mapping exercise to determine key skill gaps within the sector will feed into a strong business case for future funding needs. The skills needed to perform research and provide thought leadership for the sector will need to be provided by a cluster of aerospace experts in Christchurch. Inviting experts to join this cluster, deliver guest lectures and offer mentoring will provide aerospace start-ups with invaluable expertise.

7.6 Pathways to attract and expand businesses

Goal #1

To attract twenty aerospace companies to Christchurch by 2025.

Goal #2

To develop Christchurch into an interconnected, collaborative aerospace start-up hub.

Goal #3

To encourage diversification of existing Christchurch businesses toward aerospace-related activities.

[57] Hanushek, E. A., Schwerdt, G., Woessmann, L. and Zhang, L. (2017). General education, vocational education, and labor-market outcomes over the lifecycle. Journal of Human Resources, 52(1), 48–87.
[58] Fabriko. (2019). Mission to Mars.
[59] Cashmere Satellite Team. (2018). About.

To ensure that the benefits of aerospace are realised, local organisations must direct their resources to help companies develop, grow, and become world leaders in their industries by providing mentoring and access to capital. This includes research and development through to full-scale manufacturing. It may also involve prioritising aerospace as a key growth sector and offering specialised grants, as well as approaching large international aerospace companies for sponsored and collaborative research initiatives.

As established in Section 5 of this report, a number of capability gaps exist in the Christchurch aerospace ecosystem. In particular, Christchurch could benefit from more depth within the following fields:

- Aerospace business accelerators
- Private aerospace research services
- Satellite services
- Ground stations
- Aerospace logistics and tracking
- Aerospace professional services offerings
- Aerospace hardware maintenance services

In light of the city's ambition to build a cohesive aerospace offering, initiatives that are likely to fill these gaps and deliver the most significant economic contribution should be prioritised. This could be achieved by attracting both national and multi-national organisations to Christchurch or by facilitating business transition.

Key initiatives identified include:

	Action items	Key stakeholders
1	**Quick win** Communicate examples of Christchurch aerospace excellence with the world and engage in "why Christchurch" storytelling.	All
2	**Quick win** Develop lessons learned from success factors for start-ups in aerospace, reasons for start-up failures in aerospace, and communicate what Christchurch can offer.	Aerospace Advisory Group
3	**Quick win** Continue to develop aerospace research partner programmes with international universities and 'sister cities' to increase international exposure.	University of Canterbury, ChristchurchNZ, Aerospace Advisory Group

	Action items	Key stakeholders
4	**Long-term** Introduce financial incentives for aerospace companies.	ChristchurchNZ, Christchurch City Council
5	**Long-term** Fund the development of an aerospace-specific start-up incubator to accelerate businesses.	Industry, MBIE, New Zealand Venture Investment Fund, Canterbury Angels, Angel Association of New Zealand
6	**Long-term** Improve access to capital by establishing government joint ventures and/or co-investment arrangements with domestic and international capital providers.	Industry and MBIE

7.6.1 Business attraction and transition

Companies at different stages of the business maturity require different types of funding. Early-stage companies, which are usually heavily R&D-intensive and capital-constrained, benefit significantly from both government funding and third party alignment. Indeed, government grants and/or awards not only assist with funding vital R&D, prototyping and eventual commercialisation, they also serve as quality signals to capital providers. Research has shown recipients of such funding to be as much as 12% more likely to receive subsequent venture capital funding.[60] Alignment with credible third parties, such as research institutes, industry bodies, and large participants also has the opportunity to raise the likelihood of a successful capital raise.[61]

A lack of connected capital, particularly in the post-commercialisation stage is a common criticism of the New Zealand business environment. If required, approaching foreign capital providers may bridge this investment gap. To raise awareness around Christchurch's aerospace investment domain, the following initiatives may prove useful:

- Preparing a portfolio of success stories to communicate how Christchurch aerospace solutions have been embraced internationally, how they have received support, and the results of such solutions.
- Preparing marketing collateral for Christchurch aerospace firms attempting to pursue international customers and/or secure connected capital abroad. This includes graphics, videos, and actionable documents alongside high-level statements that emphasise Christchurch's unique qualities and rebut misconceptions.

To ensure that local aerospace companies receive the growth capital they require, additional initiatives may include:

- Establishing a dedicated funding stream for both Christchurch and New Zealand based aerospace companies. This will most likely be a joint investment by government and specialised local or international venture companies. This model has been highly successful in the agritech sector, where companies such as Finistere Ventures have made multiple investments in early-stage New Zealand companies. Venture capital companies with a

[60] Islam, M., Fremeth, A., & Marcus, A. (2018, January). Signaling by early stage startups: US government research grants and venture capital funding. Journal of Business Venturing, 33(1), 35-51.
[61] Plummer, L. A., Allison, T. H., & Connelly, B. L. (2015, June). Better Together? Signaling Interactions in New Venture Pursuit of Initial External Capital. The Academy of Management Journal, 59(5).

demonstrated commitment to space and/or aerospace companies include Khosla Ventures and Bessemer Venture Partners.
- Introducing annual awards for excellence in aerospace alongside a prize of significant monetary value.

For international companies, the location decision will primarily be a function of talent depth, proximity to similar businesses, access to testing facilities, distance to key markets and business incentives. While aerospace-specific tax incentives are a common feature abroad, it is unlikely the New Zealand government would consider regional tax breaks for large international companies. However, it is within the power of local government to ease regulatory constraints with respect to land zoning and permits. In this way, there must be a concerted effort to direct local government resources to aerospace and ensure as smooth a business as possible for international companies wishing to locate to Christchurch. This will also involve listening to the needs of new aerospace companies and helping them make the right connections in the sector.

7.6.2 Establishing an end-to-end aerospace incubator

Stakeholder consultations consistently reveal the importance of commercialisation and patenting, in addition to deep-tech research. Internationally, hardware-specific accelerators have begun to bridge this commercialisation gap. A key success story is Hax, a Shenzhen based hardware accelerator that assists entrepreneurs with everything from materials sourcing, supply chain, prototyping, design, and engineering to full-scale manufacturing and product marketing.[62]

Likewise, providing hardware, machining and software development facilities in one place through an aerospace-specific incubator in Christchurch will be central to achieving the city's goal of developing a cohesive aerospace offering. This may be funded directly by the New Zealand government, or via joint a joint investment initiative with venture capital organisations.

7.6.3 Supporting actions

Businesses within the aerospace sector often require access to significant levels of advanced infrastructure to support their operations, whether that may be technology firms attempting to upload and download large data packets to and from the cloud, or spacecraft manufacturers transporting large components off- and onsite. The size of the asset base at risk, particularly for large aerospace hardware companies, also means that Christchurch needs to de-risk itself as a business location.

[62] HAX. (2019). Shenzhen.

8 Potential regional economic benefits

A wide range of potential benefits could result from implementation of one or many of the action points suggested in this report.

8.1 Creating jobs and supporting employment

The development of an aerospace sector could support employment growth in both Christchurch and the wider Canterbury Region. Labour demand would be driven up as people are encouraged to live and invest in Christchurch to work for or near aerospace businesses. A range of sectors would benefit from the aerospace sector such as manufacturing, research and development, along with services.

Canterbury's labour market also has room to accommodate this growth: for instance, the average annual underutilisation rate (which is the proportion of people working less hours than they wish to) in Canterbury was 11% for the year ending June 2019. This rate is similar to the national average of 11%, but indicates that there is spare capacity in the region.

8.2 Boosting productivity

International evidence suggests that aerospace-related businesses punch well above their weight in terms of productivity. In fact, labour productivity in the UK aerospace sector increased by close to 50% between 2009 and 2016, and the sector enjoys productivity levels 40% higher than the UK manufacturing sector as a whole.[63] This accomplishment is mainly attributed to strong nation-wide investment in education and technological innovation. Given sluggish growth in Christchurch's own productivity levels, a growing aerospace space sector presents an opportunity for Christchurch to future-proof its economy and kick-start a new growth trajectory.

Aerospace workers with STEM backgrounds also earn some of the highest annual salaries in the USA, while having a lower minimum education requirement in comparison to other STEM fields.[64] However, these benefits are not necessarily contained within just the aerospace sector.

8.3 Technology and knowledge spillovers to other sectors

As large aerospace companies locate to or grow organically in Christchurch, knowledge spillovers and economies of agglomeration in the form of technology sharing, adjacent patenting activity, technical talent and commercial expertise are likely to benefit other sectors.[65] Furthermore, large aerospace companies often act as a magnet for small suppliers and contractors,[66] and as aerospace's contribution to Christchurch GDP rises and incomes grow, the Christchurch economy is well placed to reap the benefits of higher spending and increased business activity more broadly.

Opportunities for seemingly unrelated industries may also emerge as a result of a thriving aerospace sector in Christchurch. Deloitte consultations revealed a desire to position Christchurch as a 'space habitat' or 'space port' over the long-term. This may include creating a space tourism plan and leveraging off the 'dark skies' around Tekapo or Christchurch as a gateway to Antarctica. Indeed, tourism is already an important sector for Christchurch, with international visitors spending just over $2.6b in the year to July 2019. On both a per capita and per square kilometre basis, Christchurch's tourism revenue outstrips both Wellington and Auckland.[67]

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[63] Aerospace Technology Institute. (2018, February). UK aerospace productivity growth strong, but uneven.
[64] Bureau of Labor Statistics. (2014). STEM 101: Intro to tomorrow's jobs. Occupational Outlook Quarterly.
[65] Buzard, K., Carlino, G. A., Hunt, R. M., Carr, J., & Smith, T. E. (2017). Localized Knowledge Spillovers: Evidence from the Spatial Clustering of R&D Labs and Patent Citations. FRB of Philadelphia Working Paper No. 17-32.
[66] Niosi, J., & Zhegu, M. (2005, March). Aerospace Clusters: Local or Global Knowledge Spillovers? Industry and Innovation, 12(1), 1–25.
[67] Ministry of Business, Innovation & Employment. (2018). Monthly tourism spend grouped by RTO and product category.

8.4 Reputation effects

Christchurch may leverage the high-tech nature of the aerospace sector to showcase the city's capabilities. Benefits may arise to businesses and suppliers undertaking innovative and complex projects. For instance, engineering firms in New Zealand tended to receive more business opportunities as a result of supplying Rocket Lab.[68] As seen with Rocket Lab's launch sites, initiatives within the aerospace sector could also become tourist attractions in their own right.

8.5 International collaborations

Collaboration is often considered a key ingredient for 'frontier' or 'creative' innovation to take place.[69] Collaborating with a group of open-minded people who can quickly validate the merits of an idea and help build upon them may accelerate the process of iterative thinking, and speed up the innovation process.[70] These initiatives usually take the form of research, co-investment, and academic knowledge exchanges.

Collaboration may also result in new products, patents, or solutions to problems. Indeed, evidence from Chile and Colombia shows that joint R&D exercises may increase the propensity of firms to introduce new products, and to patent them.[71] Previous research also demonstrates the risk-sharing qualities of joint R&D initiatives.[72] This suggests international collaborations may stimulate additional R&D investment and encourage better commercialisation of research.

8.6 Applications in the primary sector

The Christchurch aerospace sector may support Canterbury's thriving local primary sector through the transfer of technology and knowledge, creating economies of scale, and ensuring the sector makes the changes necessary to be carbon neutral over the long term.

There are many applications of aerospace technologies to primary sector activities. An important example of this is precision agriculture, which is a collection of technologies and techniques that address key challenges in a range of farming systems, including viticulture, cropping, and dairying. These tools helps famers address productivity, reduce inputs and maximise yield potential.

Table 8.1 Examples of primary sector applications for aerospace technology

Activity	Description
Pasture management	The utilisation of drones, area surveying, and satellites for crop monitoring. Activities undertaken in pasture management include ranking paddocks, daily allocation of pasture, and identifying paddocks for pasture renewal.[73]
Water monitoring	Precision agriculture used to enable highly precise, variable irrigation systems that optimise water use.
Satellite Earth Observation	A form of remote sensing that gathers information about the Earth's surface and atmosphere at vertical distances of up to 36,000km. EO may be used to measure various aspects of crops such as weeds leaf index area, biomass, crop height, and growth stage. These measurements and assessments usually inform yield projections.[74]

Source: Deloitte Access Economics

[68] Moore, D., Ryan, M., Davis-Colley, M. (2016). Economic Impact Analysis of the Development of a Rocket Industry in New Zealand. Wellington: Sapere.
[69] Department of Industry, Tourism and Resources. (2006). Collaboration and other factors influecing innovation novelty in Australian businesses.
[70] Deloitte Access Economics (2014). The collaborative economy: a report for Google.
[71] Marotta, D., Mark, M., Blom, A., & Thorn, K. (2016). Human Capital and University-Industry Linkages' Role in Fostering Firm Innovation: An Empirical Study of Chile and Colombia. World Bank Policy Research Working Paper No. 4443.
[72] Baba, Y., Shichijo, N., & Sedita, S. (2009). How do collaborations with universities affect firms' innovative performance? The role of "Pasteur scientists" in the advanced materials field. Research Policy, 38(5), 756-764.
[73] Stuff NZ. (2017, September 12). Pasture measurement - the new technology.
[74] Agriculture and Horticulture Development Board. (2017). Satellites for agriculture. Kenilworth: AHDB.

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Appendix A: Competitive economic indicators

The following analyses give an indication of Christchurch's comparative advantages as an aerospace hub, relative to Wellington and Auckland.

Statistics directly or indirectly referred to in our report are emboldened.

A.1. Regional sector statistics

Table 9.1 Sector share

Indicator	Christchurch	Wellington	Auckland
Normalised sector share score (GDP) [a, b, 75]			
Manufacturing	**1.10**	**0.77**	**0.99**
Primary Manufacturing	**1.02**	**0.97**	**0.84**
Other Manufacturing	**1.24**	**0.41**	**1.26**
Information Media, Telecommunications and Other Services	0.78	1.38	1.25
Professional, Scientific, and Technical Services	0.99	1.50	1.21
Education and Training	0.94	0.91	1.01
Normalised sector share score (Employment) [a, b, 76]			
Manufacturing	**1.15**	**0.51**	**0.96**
Transport, Storage, Information Media, and Telecommunications	0.99	0.88	0.88
Professional, Scientific, and Technical Services	0.89	0.48	1.33
Education and Training	0.89	1.05	0.97

Source: Statistics New Zealand, Deloitte Access Economics analysis

[a] Data only available for Canterbury region

[b] Industry share score is calculated as ((regional sector value/regional total value)/(national sector value/national total value)), and gives an indication of relative concentration relative to the national average

[75] Statistics New Zealand. (2018). Gross domestic product, by region and industry (Annual-Mar).
[76] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).

Table A.12 Sector earnings

Indicator	Christchurch	Wellington	Auckland
Median earnings [a, 77]			
Manufacturing	**$ 13,980**	**$ 12,770**	**$ 14,270**
Transport, Storage, Information Media, and Telecommunications	$ 14,490	$ 15,600	$ 15,120
Professional, Scientific, and Technical Services	$ 16,800	$ 18,750	$ 17,500
Education and Training	$ 13,490	$ 15,020	$ 13,870
Median earnings growth (4-year CAGR, 2014-2018) [a, 78]			
Manufacturing	**3.2%**	**2.9%**	**3.2%**
Transport, Storage, Information Media, and Telecommunications	3.4%	2.9%	3.0%
Professional, Scientific, and Technical Services	3.2%	1.8%	3.2%
Education and Training	0.4%	1.3%	0.0%

Source: Statistics New Zealand, Deloitte Access Economics analysis

[a] Data only available for Canterbury region

A.2. Regional economy statistics

Table A.21 Gross domestic product (GDP)

Indicator	Christchurch	Wellington	Auckland
Regional GDP growth (4-year CAGR, 2014-2018) [a, 79]			
Manufacturing	**3.5%**	**4.6%**	**3.8%**
Primary Manufacturing	4.0%	4.5%	1.7%
Other Manufacturing	2.7%	4.7%	6.5%
Information Media, Telecommunications and Other Services	2.8%	1.4%	4.6%
Professional, Scientific, and Technical Services	7.7%	6.2%	7.3%
Education and Training	4.4%	3.0%	5.4%
Regional GDP per capita			
2018 nominal value [80]	$ 64,814	$ 118,360	$ 64,223
4-year CAGR (2014 - 2018) [81, a]	1.5%	2.8%	4.3%
Change in regional GDP per capita as a percentage of national average (2000 – 2017) [82]	139%	82%	85%

Source: Statistics New Zealand, New Zealand Productivity Commission, Deloitte Access Economics analysis

[a] Data only available for Canterbury region

[77] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).
[78] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).
[79] Statistics New Zealand. (2018). Infoshare tables: Gross domestic product, by region and industry (Annual-Mar).
[80] MBIE. (2018). MTAGDP estimates: GDP per capita.
[81] Statistics New Zealand. (2018). Infoshare tables: Gross domestic product per person, by region (Annual-Mar).
[82] New Zealand Productivity Commission. (2018). Productivity by the numbers: 2019.

Table A.22 Employment

Indicator	Christchurch	Wellington	Auckland
Employment growth by sector (4-year CAGR, 2014-2018) [a, 83]			
Manufacturing	**1.1%**	**1.7%**	**2.3%**
Transport, Storage, Information Media, and Telecommunications	2.7%	(2.3%)	2.6%
Professional, Scientific, and Technical Services	3.2%	3.5%	5.8%
Education and Training	2.9%	1.9%	4.6%

Source: Statistics New Zealand, Deloitte Access Economics analysis
[a] Data only available for Canterbury region

Table A.23 Productivity and innovation

Indicator	Christchurch	Wellington	Auckland
Unadjusted spatial productivity premium relative to Auckland (2016) [84]	**(12.1%)**	**(4.2%)**	**-**
Average productivity (2014-2016) [85]			
Manufacturing	**45.5%**	**78.2%**	**54.3%**
Professional, Scientific, and Technical Services	66.6%	77.2%	62.6%
10-year productivity increase (2004-2006 to 2014-2016) [86]			
Manufacturing	**18.4%**	**18.3%**	**(3.5%)**
Professional, Scientific, and Technical Services	19.2%	4.2%	(3.9%)
Average yearly intellectual property applications (2014-2018) [a, 87]			
Patents	**132**	**118**	**488**
Designs	37	41	193

Source: Motu Economic Research, Christchurch City Council, IPONZ
[a] Data only available for Canterbury region

Table A.24 Infrastructure

Indicator	Christchurch	Wellington	Auckland
Infrastructure spending (2016-2018) [88]			
Total	$ 429m	$ 150m	$ 1,069m
Bridges & structures replacement	$ 0m	$ 4m	$ 2m
Minor Improvements	$ 16m	$ 17m	$ 65m
New roads & bridges	$ 283m	$ 79m	$ 366m
Road reconstruction	$ 108m	$ 50m	$ 626m
Traffic management	$ 22m	$ 0m	$ 10m

Source: New Zealand Transport Agency, Deloitte Access Economics Analysis

[83] Statistics New Zealand. (2018). Infoshare tables: Regional Council (2-way) by LEED ANZSIC06 Level 1 (2-way) (Qrtly-Mar/Jun/Sep/Dec).
[84] Maré, D. C. (2016). Urban productivity estimation with heterogeneous prices and labour. Motu Working Paper 16-21.
[85] Provided by Christchurch City Council.
[86] Provided by Christchurch City Council.
[87] New Zealand Intellectual Property Office. (2019, June). Facts and figures.
[88] NZ Transport Agency. (2018). Expenditure, on major transport-related activities by Approved Organisations, in each region, and in NZ...over the last 10 years.

A.3. Regional community statistics

Table A.31 Regional cost

Indicator	Christchurch	Wellington	Auckland
Regional CPI change (4-year CAGR, 2014-2018) [a, 89]			
Total	0.8%	1.0%	1.3%
Rental	**(0.3%)**	**5.2%**	**3.6%**
Food	0.4%	0.6%	0.8%
Health	1.1%	0.8%	1.5%
Transport	(1.2%)	(0.8%)	(0.4%)
Average residential rates for 2018 [90]	$ 2,262	$ 2,552	$ 3,136

Source: Statistics New Zealand, New Zealand Taxpayers' Union, Deloitte Access Economics Analysis
[a] Data only available for Canterbury region

Table A.32 Regional attractiveness

Indicator	Christchurch	Wellington	Auckland
Population by Territorial Authority Area [91]			
2018 nominal value	0.4m	0.2m	1.7m
4-year CAGR (2014-2018)	1.8%	2.0%	2.7%
Population density per square kilometre [92]	242	746	105
Tourism spend as of 2019 [93]			
Nominal value	$ 2.6b	$ 1.9b	$ 8.4b
Per capita	**$ 6.2k**	**$ 4.6k**	**$ 4.9k**
Per square kilometre	**$ 1.5m**	**$ 1.1m**	**$ 0.5m**
"Net good" quality of life response [94]	83%	88%	82%
Average underutilization rate (2014 – 2018) [95]	10.2	12.5	12.1

Source: Statistics New Zealand, MBIE, Deloitte Access Economics Analysis

[89] Statistics New Zealand. (2018). Infoshare tables: CPI Regional Groups (Broad Regions) (Qrtly-Mar/Jun/Sep/Dec).
[90] New Zealand Taxpayers' Union. (2018). 2018 Ratepayers' Report.
[91] Statistics New Zealand. (2018). Infoshare tables: Estimated Resident Population for Territorial Authority Areas, at 30 June(1996+) (Annual-Jun).
[92] Statistics New Zealand. (2018). Infoshare tables: Estimated Resident Population for Territorial Authority Areas, at 30 June(1996+) (Annual-Jun). Retrieved from Statistics New Zealand: http://archive.stats.govt.nz/infoshare/, Statistics New Zealand. (2018). Territorial Authority 2018 (generalised).
[93] Ministry of Business, Innovation & Employment. (2019). Monthly tourism spend grouped by RTO and product category.
[94] Quality of Life Project. (2018). Quality of Life Survey 2018: Topline Report.
[95] Statistics New Zealand. (2018). Infoshare tables: Underutilisation by Sex by Regional Council (Annual-Dec).

Appendix B: Stakeholder workshop outputs

9.2 Innovation and test-bed capabilities

Theme	Goal	Action points
Innovation and test-beds	Develop world-class test bed capabilities to become a one stop shop for launch, mission control, and monitoring.	1. Develop a compelling test bed facility and package testing iteration option to assist with test positioning. 2. Development of a start-up prospectus for fast realisation of testing capabilities and launch ranges. 3. Establishing regulatory pre-approved locations and zones for test bed development.

9.3 Knowledge sharing

Theme	Goal	Action points
Knowledge sharing	Link together upstream and downstream aerospace technologies in a coherent way to assist with market validation, demand determination and giving a clear line of sight to potential entrants.	1. Develop a capability directory to map the Christchurch aerospace value chain, from precision manufacturers and engineers to authorised resellers of satellite data. 2. Creating local and international awareness of aerospace in Christchurch to assist in prioritising this sector. 3. Establish an open source space data platform, or 'data cube', to enable data-centric entrepreneurship and AI research.

9.4 Education and training

Theme	Goal	Action points
Education and training	To build and retain a workforce of the appropriate size, scope, and depth to accommodate the labour demands of a growing aerospace industry.	1. Establish undergraduate and postgraduate programmes to support both aerospace or aeronautical engineering and aerospace science.
	To ensure that emerging aerospace industry demands are met by continuous training and broad education programmes.	1. Assess the demand for skills required now and in the future, and assess which training programmes are needed to ensure a robust talent pipeline. 2. Continue to drive perception change from the bottom-up by actively promoting and funding Aerospace education programmes in schools.
	To build the eminence of the sector and position aerospace as an attractive career pathway for a broad cross-section of young people.	1. Continue to strengthen the relationship between industry and the tertiary sector by establishing aerospace internships and work experience programmes. 2. Establish a regional fees-free and/or scholarship programme for young students wishing to pursue a career in aerospace, with pro-active support for diversity.
	To position Christchurch as an internationally recognised and globally distinctive centre of excellence for industry-integrated research and development for aerospace.	1. Investigate the establishment of a Space Research Centre to provide R&D focus and expertise, as well as participating in key space events and conferences. 2. Identify and develop 'cornerstone projects' supported by both government and industry designed to encourage commercialisation in operational environments.

9.5 Pathways to attract and expand businesses

Theme	Goal	Action points
Pathways to attract and expand businesses	To attract twenty aerospace companies to Christchurch by 2025.	1. Introduce financial incentives for aerospace companies.
		2. Communicate examples of Christchurch aerospace excellence with the world and engage in "why Christchurch" storytelling.
	To develop Christchurch into an interconnected, collaborative aerospace start-up hub.	1. Develop lessons learned from success factors for start-ups in aerospace, reasons for start-up failures in aerospace, and communicate what Christchurch can offer.
		2. Fund the development of an aerospace-specific start-up incubator to accelerate businesses.
		3. Establish Aerospace partner programmes with international universities and 'sister cities' to increase international exposure.
	To encourage diversification of existing Christchurch businesses toward aerospace-related activities.	1. Improve access to capital by establishing government joint ventures and/or co-investment arrangements with domestic and international capital providers.

Limitation of our work

General use restriction

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