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New Zealand Space Sector:
Its value, scope and structure

Ministry of Business, Innovation and Employment
November 2019

Deloitte
Access Economics

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Glossary

ANZSIC	Australian and New Zealand Standard Industrial Classification
CNES	French National Centre for Space Studies
DLR	German Aerospace Centre
DTH	Direct-to-home broadcasting
EBITDA	Earnings before interest, taxes, depreciation, and amortisation
EO	Earth observation
ESA	European Space Agency
FTE	Full-time equivalent
GDP	Gross domestic product
GNSS	Global navigation and satellite system
GOS	Gross operating surplus
IO	Input-output
JAXA	Japanese Aerospace Exploration Agency
LEO	Low Earth orbit
LINZ	Land Information New Zealand
MBIE	Ministry of Business, Innovation and Employment (New Zealand)
MOU	Memorandum of understanding
NASA	National Aeronautics and Space Administration (United States)
NZD	New Zealand dollars
OECD	Organisation for Economic Cooperation and Development
PNT	Position, navigation and timing
R&D	Research and development

This version of the report is updated as of November 2019 to reflect the change in the definition from space economy to space sector

Acknowledgements

Deloitte Access Economics gratefully acknowledges the assistance of all stakeholders involved in the preparation of this report.

The survey data used in this report could not have been collected without the enthusiastic co-operation of multiple organisations who agreed to distribute the survey on behalf of Deloitte Access Economics. New Zealand's SpaceBase platform, built and administered by Emeline Paat-Dahlstrom and Eric Dahlstrom, also served as an invaluable resource when determining which companies to include in the survey. A list of organisations who offered to distribute this survey is provided in Appendix A.

Organisations also offered to share their insights confidentially. On technical aspects, in particular, a wide range of space-related organisations and subject matter experts offered valuable insights and resources. These were obtained by way of in-person stakeholder consultations, phone calls, and email correspondence.

Deloitte Access Economics prioritises the confidentiality of survey participants

This report presents independent research conducted by Deloitte Access Economics and commissioned by the Ministry of Business, Innovation and Employment (MBIE). MBIE were independent of the collection, analysis, and interpretation of respondent data. All data collected remained purely confidential and only accessible to Deloitte Access Economics for the purposes of analysis and aggregation.

Executive Summary

New Zealand is a unique example of a space sector almost entirely driven by commercial activity

MBIE engaged Deloitte Access Economics to define and map New Zealand's space sector and estimate the contribution it makes to New Zealand's economy.

The space sector comprises a range of actors and activities involved with the access and use of space, and the development and application of space-based services and products across both public and private sectors. To define the New Zealand space sector this report draws on the detailed definitions used in studies of other space sectors, which have in turn built on definitions developed by the Organisation for Economic Cooperation and Development (OECD).

Key insights on New Zealand's space sector

Deloitte Access Economics distributed a survey to organisations across New Zealand's space sector. Out of the 220 surveys distributed and 119 unique responses, 104 responses were deemed suitable for analysis. The information gathered from survey responses was augmented with desktop research, financial data and direct consultations.

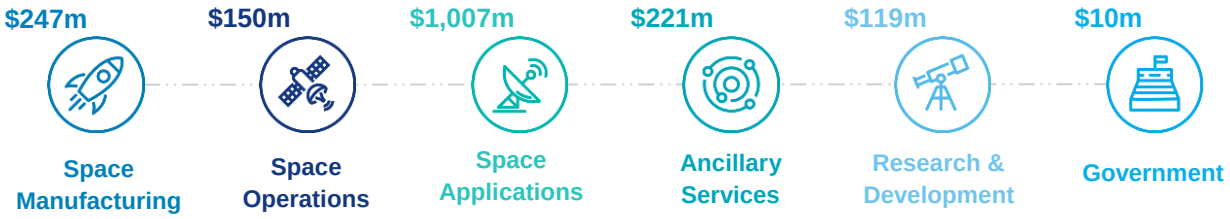
The survey results and additional analysis show that the New Zealand space sector:

- Is New Space-driven, characterised by a mix of start-up and well-established, small and large, entrepreneur-driven and privately-funded space companies which service both government and non-government customers. New Space is in contrast with traditional space economies where large-scale government activity has been a major driver.
- Has strong Space Manufacturing and Space Applications sub-sectors, and cutting-edge research and development capability within several universities across the country.
- Draws on local as well as international talent, and has strong connections with the global space sector.

Total revenue (gross output) of New Zealand's space sector

The total **estimated revenue of the space sector is $1.75 billion in 2018-19**, representing 0.27% of global space sector revenues.

Figure 1.1 A breakdown of the estimated space revenue across sub-sectors



Source: Deloitte Access Economics

Space Manufacturing: includes the design and/or manufacture of space equipment and subsystems.

Space Operations: include the launch and/or operation of satellites and/or spacecraft.

Space Applications: include applications making use of satellite signals and data.

Ancillary Services: include organisations involved in the provision of specialised support services.

Research & Development: space related research & development.

Government: regulatory oversight, space related policy-making and sector development functions.

Economic contribution of New Zealand's space sector

Drawing on data from the survey and financial reports of key participants in the space sector, the economic contribution analysis estimates the direct and indirect value added to New Zealand's economy from the space sector.

- **The direct contribution of the space sector** to New Zealand GDP (value added by the activities of businesses within the space sector) in 2018-19 was **$897 million**, representing a value-added share of 51% of total revenue.
- **The indirect contribution of the space sector** to the New Zealand economy, i.e. the value added by the space sector's expenditure on goods and services used in the production process in 2018-19 was **$789 million**.
- **Space directly supports an estimated 5,000 full-time equivalent roles (FTEs).** Total employment, including indirect effects, was 12,000 FTE jobs.

This report represents the first estimate of the New Zealand space sector's size, value and composition.

The economic contribution of the space sector to New Zealand was **$1.69 billion** in 2018-19

1 This report

Purpose and scope of this report

To better understand New Zealand's space sector, MBIE engaged Deloitte Access Economics to define and map New Zealand's space sector and to estimate the economic contribution the space sector makes to New Zealand's economy.

This report provides new information about New Zealand's space sector in four key ways:

1. It defines the space sector, consistent with internationally accepted definitions.
2. It provides insights into New Zealand's space sector based on a new national survey of participants across the space sector.
3. It measures the revenue of New Zealand's space sector.
4. It measures the economic contribution of the space sector New Zealand.

As part of writing the report, Deloitte Access Economics also built the first directory of organisations in the New Zealand space sector. The directory is held by MBIE.

Approach

This report combines research and analysis from the following key focus areas:

Defining the space economy and the space sector

Space-related activities extend across multiple sectors, such as aerospace, defence, advanced manufacturing, broadcasting and telecommunications. As such, defining space-related activities for the purpose of measuring them is a challenging exercise. At the outset, this report seeks to clearly define the space sector and its activities.

This report uses the OECD definition of the space sector as a basis and draws on the detailed definitions in studies of space sectors in other economies to clarify which activities fall into individual sub-sectors.

Mapping New Zealand's space sector

Data used to inform key insights concerning New Zealand's space sector and the first space directory predominantly comes from the new bespoke survey.

About the survey:

- The survey on New Zealand's space sector was distributed in July 2019 to organisations across a range of space sub-sectors.
- The sample is nationally representative across the sub-sectors, to the extent possible. The survey was distributed to 220 organisations. The total response rate to the survey was 119 unique responses, or a 54% response rate.
- Organisations across the space sector answered questions about organisational structure, revenue, location, maturity, research and development activities as well as space expertise and capability.
- While every effort has been made to capture participants engaged in space-related activities, this is the first engagement with participants on this scale.

Measuring economic contribution

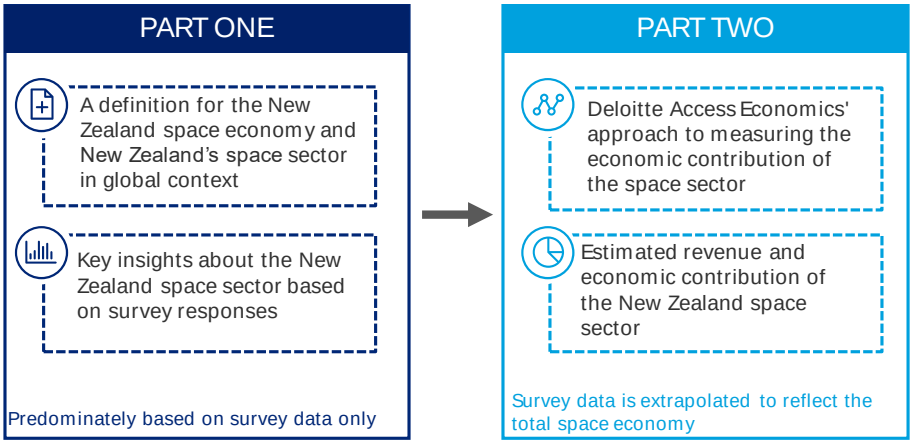
To measure the economic contribution of New Zealand's space sector, Deloitte Access Economics performed input-output (IO) modelling using survey response data as the primary input.

The survey data was supplemented with desktop research; specifically identifying current financial information for key participants across the space sector. Because the survey data only presents a sample of the total space sector, Deloitte Access Economics applied a scaling approach to extrapolate the data from the sample. Detailed information on this scaling approach is provided in Appendix D.

Outline of this report

Part I of this report defines the space sector and presents the current picture of organisations operating in New Zealand's space sector.

Part II of this report presents Deloitte Access Economics' IO modelling framework and related theory used in estimating the economic contribution of the space sector. This is divided into three sections: the total revenue or gross output of the space sector, the direct and indirect contribution in terms of both value-added and employment, and a sense check on the results.



This report includes detailed appendices, which include: the survey methodology, results and questions, which inform the analysis in Part I of this report.

The technical appendix details the modelling methodology, inputs and assumptions which informed the measurement of the economic contribution detailed in Part II of this report.

Part I

Defining the space sector and understanding its current scope and structure

2 Context

New Zealand is a unique example of a space sector primarily driven by commercial activity

A new era of space activity

Valued at NZD $647 billion in 2019, growth in the global space sector has been driven by rapid improvements in science and technology, and increasing demand for space-enabled services across a broad range of industries and countries.

Private investment in space, representing 80% of the total global space market, is expected to grow at least 3.5% per annum. Governmental budgets for space activities are also growing, with more than 80 nations establishing space agencies.

Once dominated by government activity in a handful of space-faring nations, the global space sector today is a dynamic ecosystem of public and private organisations and investors.

Key characteristics of New Space

The term *New Space* refers to a rapidly growing, global community of entrepreneurs and private actors contributing to a new era of space-related activity.

New Space is a fast-paced, competitive, and innovative sector reliant upon pockets of significant wealth, high-value early investment, highly skilled individuals, and the shouldering of risk. This is in contrast to government-driven “traditional space” activity that implemented programmes at large scale over many years or decades.

The transition from traditional space to New Space has attracted unprecedented investment and innovation. Key characteristics of New Space include:

Competition. Unprecedented competition and growth has been fostered by a changing market structure and driven the commercial use of space infrastructure and its application to industries unrelated to space. Competition between private companies and a stronger focus on cost efficiencies have facilitated innovation. For example, commercial launches have reduced the cost of low Earth Orbit (LEO) by a factor of 20 in the last decade. This is due in large part to technological improvements and changes in market requirements (lighter payloads).

Increase in private investment. Technological advances, reduced cost, and an increase in profitability have made investments in space organisations more attractive. These changes have driven record investment in space organisations internationally; venture capital investments in start-up space companies since 2000 total US$8.4 billion, with roughly 85% invested in the past four years. As private actors play a growing role, we observe a reduction in the relative importance of government activity and spending.

Public demand for data contributes to increased commercialisation. Behind this New Space era is the individual. The modern consumer’s insatiable demand for data is accommodated by a rapidly increasing number of commercial space organisations manufacturing more affordable satellites for non-traditional space sub-sectors. The main change in the shift from traditional space programmes to New Space is the drive to make more money and accelerate the process.

New Zealand's space sector is New Space-driven

Many space sectors around the world were built on large institutional space programmes. International space sectors are now expanding from traditional space models and developing their New Space activities, however, **for New Zealand there is only New Space**, and this has driven the market structure that exists today.

New Zealand is also one of the few countries from which a thriving, market-driven launch sector has emerged. Unique to the growth path of New Zealand's space sector is the presence of a major commercial launch company, Rocket Lab. While Rocket Lab is a catalytic component of New Zealand's space sector, several organisations which pre-date Rocket Lab have been able to leverage the market interest and activity generated by Rocket Lab to build on existing capability.

Beneficiaries have been able to leverage everything the New Space era embodies – agility, innovation, accessibility, and private investment. For New Zealand, the New Space development has important implications for how the space sector will develop in the future.

The New Zealand Space Agency, established in 2016 as part of MBIE, creates and oversees space policy and strategy, supports space sector development for New Zealand and engages with international partners. New Zealand's departmental space budget for 2018-19 was NZD $3.8 million and MBIE spent a further $6.02 million in 2018-19 supporting space science research.

New Zealand enacted the Outer Space and High Altitude Activities Act 2017, which established a regulatory regime to ensure the safe, responsible and secure use of space from New Zealand.

The following chapters illustrate the types of organisations and their activities in New Zealand's space sector.

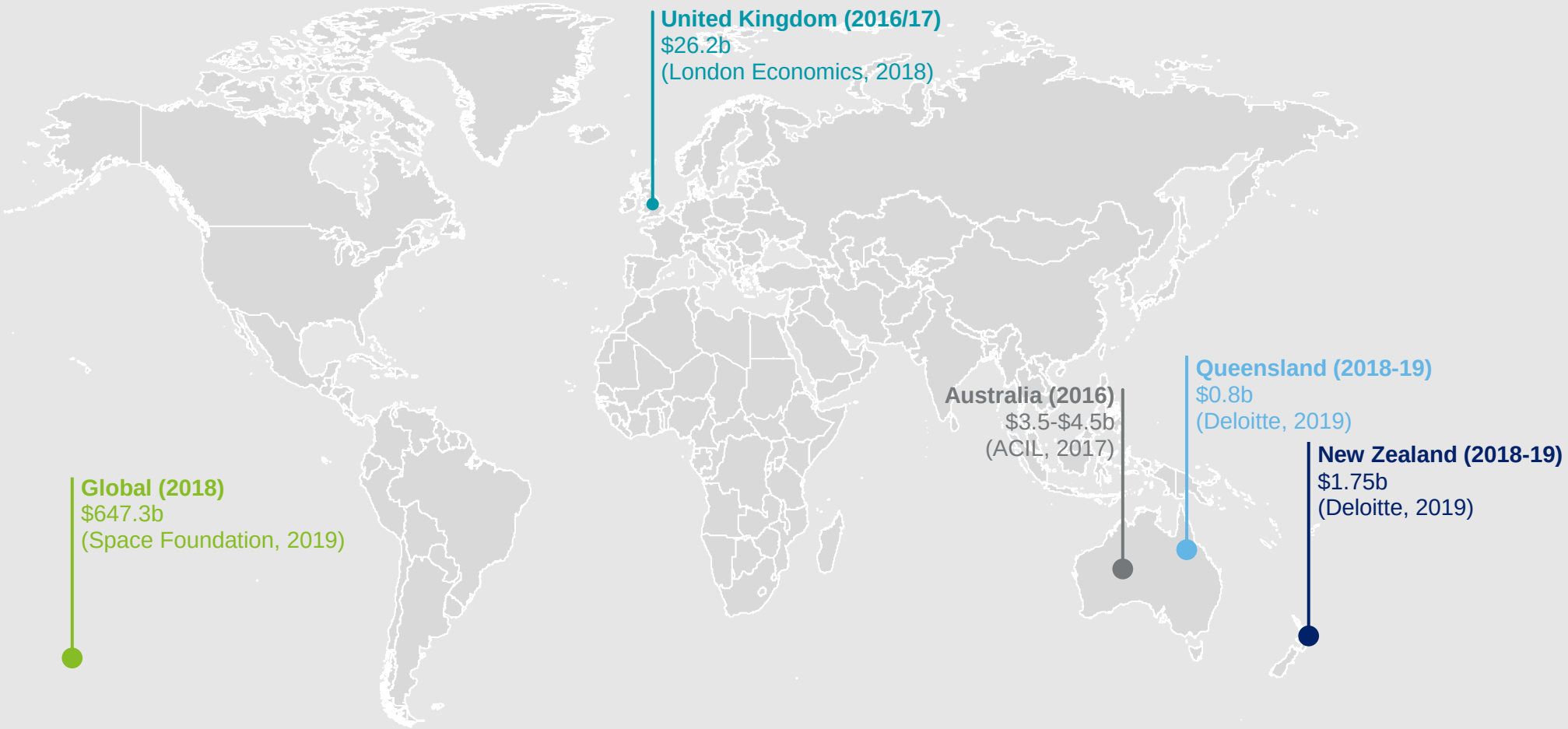
Case Study: Rocket Lab

Rocket Lab was established in 2006 and operates a launch base in Mahia in New Zealand's North Island. Within the global space context, Rocket Lab accounts for NZD $454 million in private investments for the space economy, which is 1.5% of global private investment in space.

Rocket Lab is a vertically integrated organisation, operating in core space sub-sectors such as Space Manufacturing and Space Operations. Its critical rocket inputs are predominantly self-supplied, while more than 1,700 NZ-based suppliers provide additional components and support functions. New Zealand's economy benefits from Rocket Lab's private investment and spill-over benefits from its operations. Spill-over benefits include attracting international talent and supporting the local space ecosystem. Rocket Lab's local investments also include educating schools and the general public about satellites and the benefits of space data access.

Figure 2.1 International space sector size, revenue (NZD)

This map presents a quick overview of the total revenue of the global space sector and some other international space sectors based on the key international studies referred to in this report.



3 Defining the space economy and space sector

To provide an estimate of the contribution and scope of New Zealand's space sector, it is necessary to first define it.

The breadth of today's space sector means assigning a prescriptive definition is difficult. Space technologies – both goods and services – are increasingly important to a range of consumers and, as such, the benefits derived by users are no longer exclusive to core space participants. For example, the activities associated with sending satellites into LEO generate significant economic returns, as both organisations and individuals on Earth use the data these satellites generate.

Definition of the space economy and space sector

Estimating the contribution and scope of the space sector requires careful consideration of which activities are space-related, regardless of whether they take place in space or on Earth. This section defines the space sector and identifies the relevant sub-sector activities used to guide the analysis presented in this report.

In developing a definition for New Zealand's space sector, Deloitte Access Economics has drawn from a number of reputable international sources. This allows for better continuity and more accurate comparisons across jurisdictions and time.

More specifically, this report draws on the detailed definitions in studies of other space sectors to define the space sector and to guide sub-sector classification. The international studies drawn on include a study by London Economics for the United Kingdom Space Agency and Australian studies conducted by Deloitte Access Economics and ACIL ALLEN.

These studies have in turn built on definitions developed by the Organisation for Economic Cooperation and Development (OECD), including its definition of the space economy (which is wider than the space sector and includes broader uses of space-derived technologies and applications, including by consumers) as:

"The full range of activities and the use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. Hence, it includes all public and private actors involved in developing, providing and using space-related products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities.

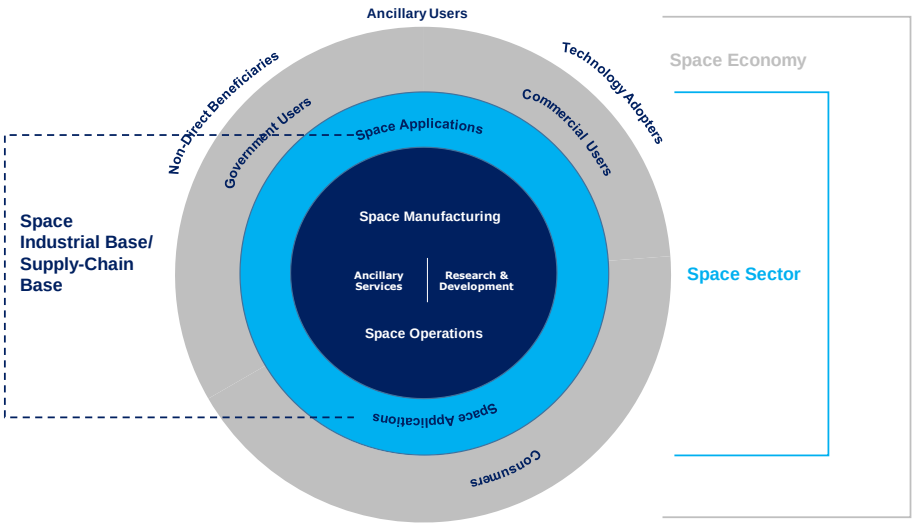
It follows that the space economy goes well beyond the space sector itself, since it also comprises the increasingly pervasive and continually changing impacts (both quantitative and qualitative) of space-derived products, services and knowledge on economy and society."

Figure 3.1 below, which is adapted from the London Economics report for the UK Space Agency, provides a detailed picture of the interrelated nature of sub-sectors within the space sector, and how they contribute to the space economy more broadly. The space sector component of this figure corresponds to the definition that will be used for the space sector in this report.

The space sector comprises the interactions between the industrial base (Space Manufacturing and Space Operations, supported by Ancillary Services, R&D and Education & Training) and Space Applications. The activities these sub-sectors are engaged in are directly related to space, or the transformation and application of space derived data.

The space economy broadens to include the way in which the space sector is engaged with non-space sectors of the economy. This includes Government, commercial users and consumers which all benefit directly from the space sector, but which are not directly engaged.

Figure 3.1 Segmentation of the space economy and space sector



Source: Deloitte Access Economics adapted from London Economics (2018)

Sub-sectors of the space sector

This section provides a description for each of the space sub-sectors.[1]

Space Manufacturing sub-sector

Space Manufacturing includes the design and/or manufacture of space equipment and subsystems, operating across many of the primary functions of the space sector, including launch activities, satellites and the ground segment.

Space Manufacturing includes:

- Launch vehicles and subsystems
- Satellites, spacecraft payloads and subsystems
- Ground segment systems and equipment-control centres and telemetry
- Suppliers of materials and components
- Scientific and engineering support
- Scientific instruments

[1] The survey included the sub-sectors 'Education and Training' and 'Other', however these sub-sectors were removed due to incomparability with the categorisation in reports on other space economies. Organisations which identified with these sub-sectors were appropriately re-allocated.

- Specialisation in nano and micro satellites (<50kg).[2]

This component of the space sector comprises prime companies with responsibility for design and assembly of complete aircraft systems and systems integrators for space and ground equipment, which in turn build on the contributions of subsystems and component suppliers.

Companies operating in this area are typically large multinationals, with strong capabilities and backgrounds in the aerospace and defence sectors, such as Boeing, Airbus, Lockheed Martin and Northrup Grumman. However, as the structure of the industry has changed over time, new players have emerged, such as Rocket Lab (NZ/USA), Blue Origin (USA), SpaceX (USA) and Virgin Galactic (UK). Many of these companies are also part of the space operations sub-sector.

Traditionally, this sub-sector has been highly dependent on institutional buyers, due to the high cost of market access. However, the landscape of this sub-sector is shifting and most of the sector's future growth is projected to come from commercial demand.

Space Operations sub-sector

Space Operations include the launch and/or operation of satellites and/or spacecraft. Firms operating in this sub-sector typically have significant space assets. The sub-sector is dominated by satellite operators which work with commercial and government users.

Specifically, Space Operations include:

- Launch services
- Launch brokerage services
- Proprietary satellite operation (incl. sale/lease of capacity)
- Third-party ground segment operation
- Ground station networks.

Space Operations is the functional component of the space supply chain. It includes the operational requirements of space systems, which typically consist of one or more Earth stations and a space station, which transmit and receive information to and from Earth stations or other space stations using radio communications.

Space Applications sub-sector

Space Applications include applications making use of satellite signals and data. Space applications fall into the following categories: Earth Observation (EO), provision of satellite communication services, and Position, Navigation and Timing (PNT), including Global Navigation and Satellite Systems (GNSS).

The Space Applications sub-sector includes:

- Direct-To-Home (DTH) broadcasting
- Fixed and mobile satellite communications services (incl. VSAT)
- Location-based signal and connectivity service providers
- Supply of user devices and equipment
- Processors of satellite data
- Earth observation services & applications[3]
- Satellite communications service providers[4]
- Satellite navigation services & applications [5]
- Users of space-enabled services
- Use of applications relying on embedded satellite signals (e.g. GPS devices and location-based services) and/or data (e.g. meteorology, commercial GIS software and geospatial products).

[2] Included to reflect New Zealand market attributes
[3] Disaggregated component of applications relying on embedded satellite signals and/or data.
[4] Ibid
[5] Ibid

Demand for space-enabled services (also known as space-derived applications) is driven by industries across the economy, as organisations become increasingly supported by satellite services. The integration and use of these services enables automation, improvement of land management, safety, and enhancing regional connectivity, for example.

Ancillary Services sub-sector

Ancillary Services include organisations involved in the provision of specialised support services.

The Ancillary Services sub-sector includes:

- Launch and satellite insurance services, including brokerage
- Financial services
- Legal services
- Software and IT services
- Market research and consultancy services
- Business incubation and development
- Construction.

Ancillary Services support all other space sub-sectors, with core space sub-sectors driving demand. The Ancillary Services sub-sector is necessarily broad, but lacks a certain degree of depth. As the space sector grows, other providers will begin to expand their services to accommodate businesses within the sector and reap the associated benefits.

Research & Development sub-sector

Crucial to the capability of the space industry is high quality research and development (R&D). Investments in research and development generate new knowledge, products and processes, allowing organisations to use the inputs available to them more efficiently and to supply improved products or services to the space sector.

The application of R&D is a key feature of the space sector; capability developed within R&D-intensive upstream organisations is commercialised by downstream organisations.[6] R&D is either commercial (research driven to deliver commercial outcomes) or academic that occurs purely in universities and research institutions to further the research area more generally.

In the space sector, R&D processes are observed in many forms: through collaborations or partnerships between universities, space agencies and organisations, or internally driven by organisations without the assistance of partnerships.

Government sub-sector

As space sectors increase in size and scope, some space-related activities require regulatory oversight, and government agencies usually establish related policy-making and sector development functions.

Recent growth in the industry has seen the establishment of space agencies outside of the traditional National Aeronautics and Space Administration (NASA), European Space Agency (ESA) and Roscosmos (the Russian Space Agency). There are now more than 80 international space agencies, several of which have been established post-2010, including in New Zealand, Australia, India and the United Kingdom (though in many cases, space activity by government agencies preceded the formation of a space agency).

[6] "Upstream" components of a supply chain typically refer to industry-intensive activities (such as the extraction of raw materials) and involve creation or flow of materials/products into an organisation for the purpose of value adding activity. "Downstream" activities often refer to the movements of goods or services created by organisations into the market or to final consumers.

Government involvement in the space sector includes:

- Policy-making
- Regulation and oversight
- Investment in space capability
- Funding of science and innovation projects
- Facilitation of domestic and international connections
- Use of space-enabled data and services.

4 Mapping New Zealand's space sector

New Zealand's space sector manufactures rockets, uses space-derived data for innovative applications and fosters deep research expertise for the next frontier.

Where Chapter 3 defined the space economy, the space sector and individual sub-sectors, this chapter goes a step further to map the individual organisations that currently operate in New Zealand's space sector.

To better understand the scope and scale of New Zealand's space sector, Deloitte Access Economics undertook a thorough data capture exercise in the form of an online survey. Organisations identified by Deloitte Access Economics as being engaged in space-related activity across the space sector (as defined in Chapter 3) were contacted and asked to participate in this exercise.

Survey results and additional analysis show that:

- The New Zealand space sector is New Space driven, characterised by a mix of start-up and well-established, small and large, entrepreneur-driven and privately-funded space companies which service both government and non-government customers. This is in contrast with traditional space sectors where large-scale government activity is a major driver.
- Has strong Space Manufacturing and Space Applications sub-sectors, and cutting-edge research and development capability within several universities across the country.
- Draws on local as well as international talent and has strong connections with the global space sector.

The New Zealand space sector is New Space-driven

The structure of the New Zealand space sector aligns with New Space and is strongly commercially focussed.

The New Zealand space sector largely consists of small, new businesses. The most commonly reported turnover range of an organisation in New Zealand's space sector was $200,000 to less than $2 million. The most commonly reported full-time equivalent (FTE) range was 1-19 employees.

However, there are some well-established companies earning significant revenue. Survey data shows there are 14 companies earning more than $10 million per annum and 16 companies employing more than 200+ employees. There were 8 respondents that identified as being part of a large multinational organisation.

Charts 4.2 and 4.3 illustrate the breakdown of revenue and number of jobs of the organisations and companies surveyed on the space sector.

Chart 4.2 Turnover range

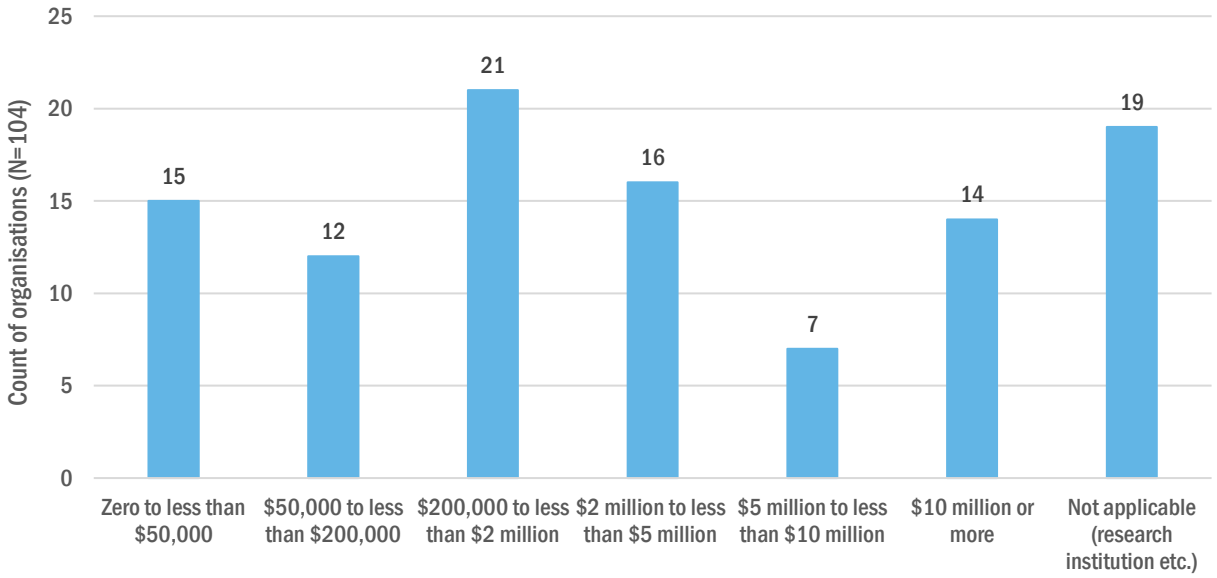
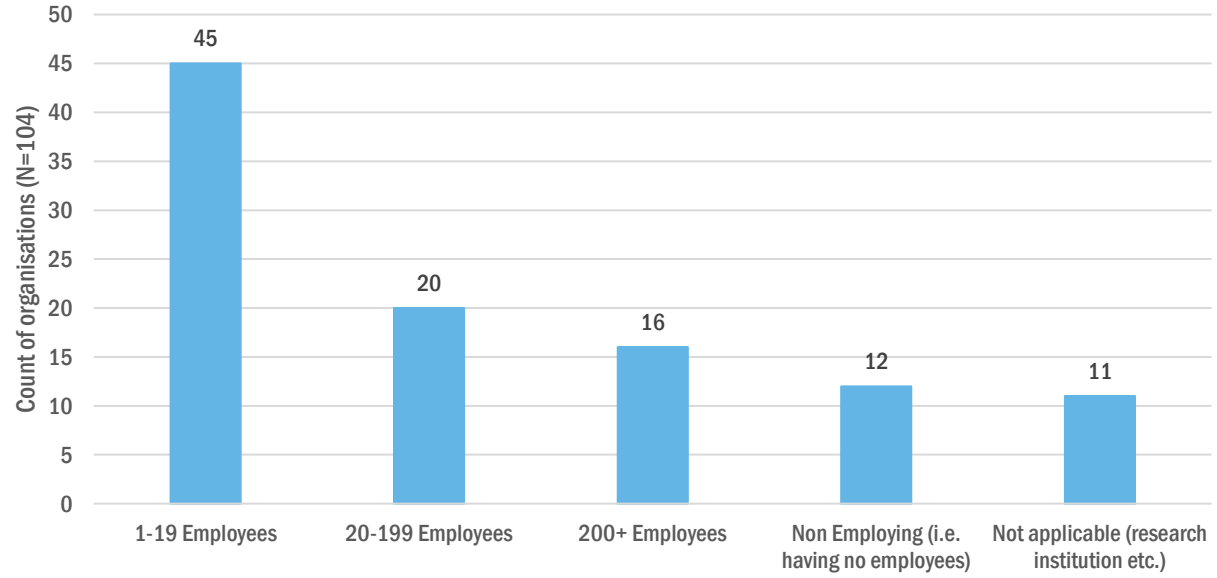
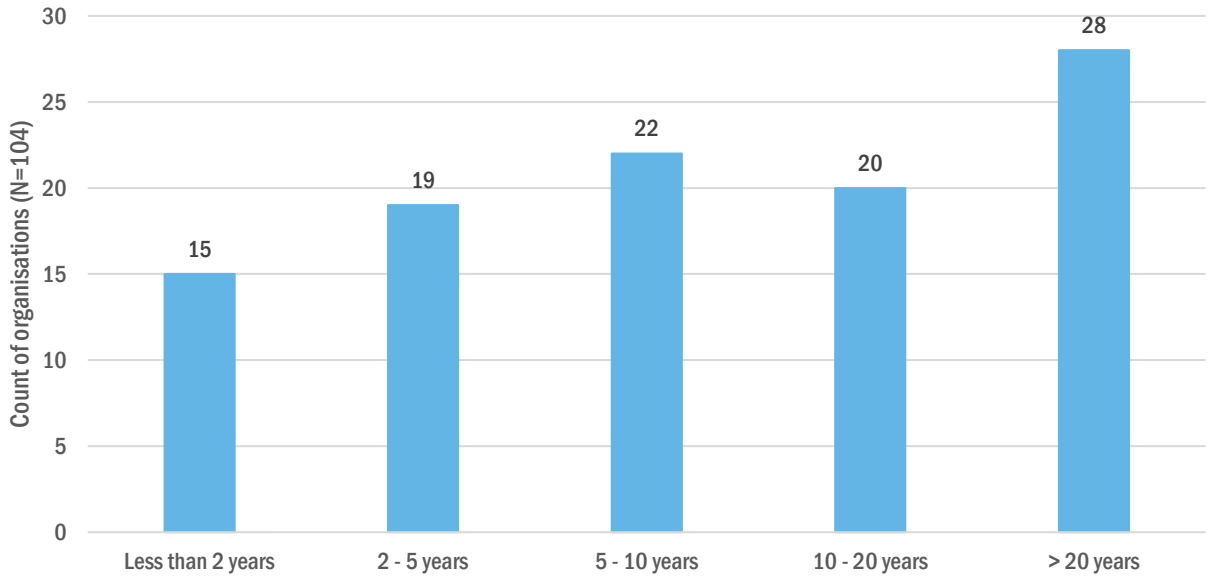


Chart 4.3 Full-time equivalents



The New Zealand space sector is a mix of old and new. Survey results show New Zealand's space sector is a mix of respondents that were almost evenly split between duration of operations fewer than 10 years and more than 10 years. Just over half of all respondents have been operating for less than 10 years.

Chart 4.1 Duration of operations



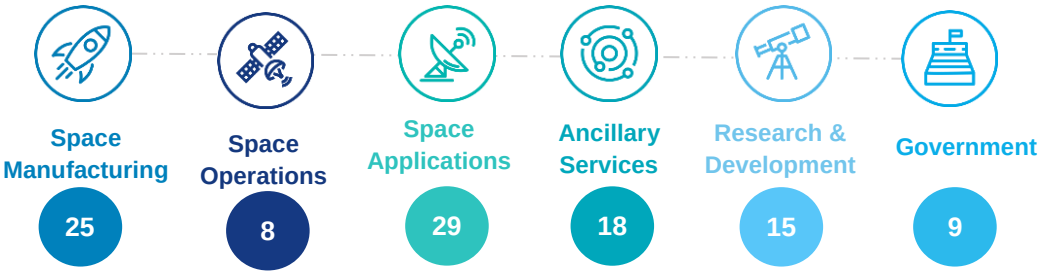
Of the firms operating for less than 10 years, a large proportion had been operating for fewer than 5 years. This period coincides with the establishment of Rocket Lab and its launch operations in New Zealand.

32 of the 104 survey respondents consider space their primary industry of operation. 17 of these organisations had only recently entered the space sector (in the past 5 years). This demonstrates the catalytic impact of Rocket Lab (whose launch operations commenced in 2016) on New Zealand's space sector.

The New Zealand space sector has strong Space Manufacturing and Space Applications sub-sectors, and cutting-edge research and development capability within several universities across the country

The figure below presents a breakdown of the survey sample across the space sub-sectors defined in Chapter 3. Figure 4.1 shows **Space Manufacturing (25 responses)** and **Space Applications (29 responses)** dominate the number of organisations present in the New Zealand space sector. These two key sub-sectors are the areas of growth in the New Space era.

Figure 4.1 Primary sub-sector of operation



What makes New Zealand's space sector unique, and therefore more focused on New Space, has been the establishment of a strong Space Manufacturing sub-sector to support upstream and downstream activities in the absence of a traditional defence sector. New Zealand's high tech manufacturing sector and the presence of organisations such as Rocket Lab are likely to have contributed to this concentration of

capability. In other developing space sectors organisations rely on transferrable skills such as those which can be found in the mining (engineering and remote operations) and defence sectors.

The Space Applications sub-sector is driven by the demand for data
Much like other international Space Applications sub-sectors, the public demand for information has led to the rapid commercialisation of activities that are derived from space data. For example, the space sector provides essential data and information for each and every one of us - from the internet and personal banking to the navigation system we use in our cars or on our phones.

New Zealand has strong research and development capability
The space sector is supported by the presence of strong R&D capability within New Zealand's universities. The highly specialised nature of the space sector means strong core research environments that actively collaborate with the private sector encourage the development of space-related capability.

R&D in New Zealand's space sector is supported by the activities of specific research units embedded within leading universities. This capability extends across the space sector to include launch and satellite manufacturing capability, astronomy and astrophysics through to the application and use of space data such as Earth Observation.

A number of these R&D facilities are engaged in commercial partnerships with industry, as demonstrated by their revenue-generating activity.

The New Zealand space sector draws on local as well as international talent and has strong connections with the global space sector

The survey results revealed New Zealand's space sector is generally home-grown; 80 of the 104 respondents reported that more than 50% of their workforce draws on New Zealanders to conduct their operations.

Almost all of the respondents have engaged with international space agencies, including NASA, ESA, JAXA, the French National Centre for Space Studies (CNES), and the German Aerospace Centre (DLR). These research organisations have also had engagement with international space organisations such as SpaceX, as well as home-grown organisations such as Rocket Lab and Tait Communications.

Where New Zealand space organisations are exporting, the majority highlighted their engagement with major private international space organisations and agencies. This indicates a high degree of capability and connection with the international space sector.

The following section presents key insights from each of the sub-sectors.

Space Manufacturing (25 responses)
This sub-sector in other space sectors often benefits from established defence and aerospace sectors. New Zealand does not have a large government-funded defence or aerospace sector, but it does have the relevant capability in advanced manufacturing. Along with the presence of a major commercial rocket launch organisation, Rocket Lab, this is likely to have driven activity in the sub-sector.

The sub-sectors' key strengths are spread across the following areas:

- Satellites, spacecraft, payloads & subsystems
- Suppliers of materials and components
- Scientific and engineering support
- Ground segment systems and equipment (control centres and telemetry).

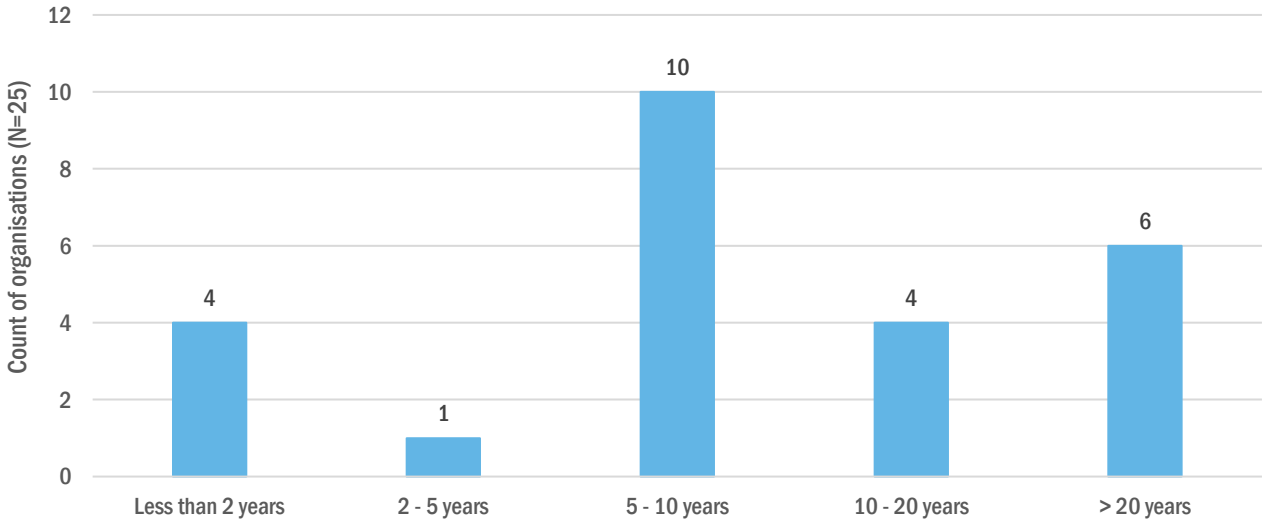
It is notable that the University of Canterbury and University of Auckland have extensive Space Manufacturing capability. The presence of specialist R&D capability lays the foundation for industry development. New Zealand expertise engaged in research collaborations and memorandums of understanding (MOUs) with international space agencies and organisations contributes to the growth of the sub-sector.

Organisations in the Space Manufacturing sub-sector are typically concentrated in and around two of New Zealand's largest cities: Christchurch and Auckland.

An example of a participant in Space Manufacturing is Fabrum Solutions. This is a precision engineering firm based in Christchurch, with additional offices in USA and Europe. Fabrum Solutions specialise in green propulsion, platform energy management, cryo-coolers, full system integration and composites manufacturing.

Survey results show that the Space Manufacturing sub-sector includes some companies that have been operating for more than 20 years (these companies are primarily suppliers of materials and components that have traditionally supplied components to other industries), alongside many younger companies.

Chart 4.4 Duration of operations



The survey results also show that a small number of Space Manufacturing companies are earning revenue of $10 million or more and employing 200+ people. The majority of companies in this sector, however, earn less than $5 million in turnover and employ fewer than 20 people.

Generally, respondents from small Space Manufacturing companies (such as those earning less than $5 million in turnover and less than 20 employees) are suppliers of materials and components, or provide scientific and engineering support. While larger companies (with turnover greater than $5 million and more than 20 employees) are engaged in activities related to ground segment systems and equipment and satellite, spacecraft, payloads and subsystems.

Chart 4.5 Turnover range

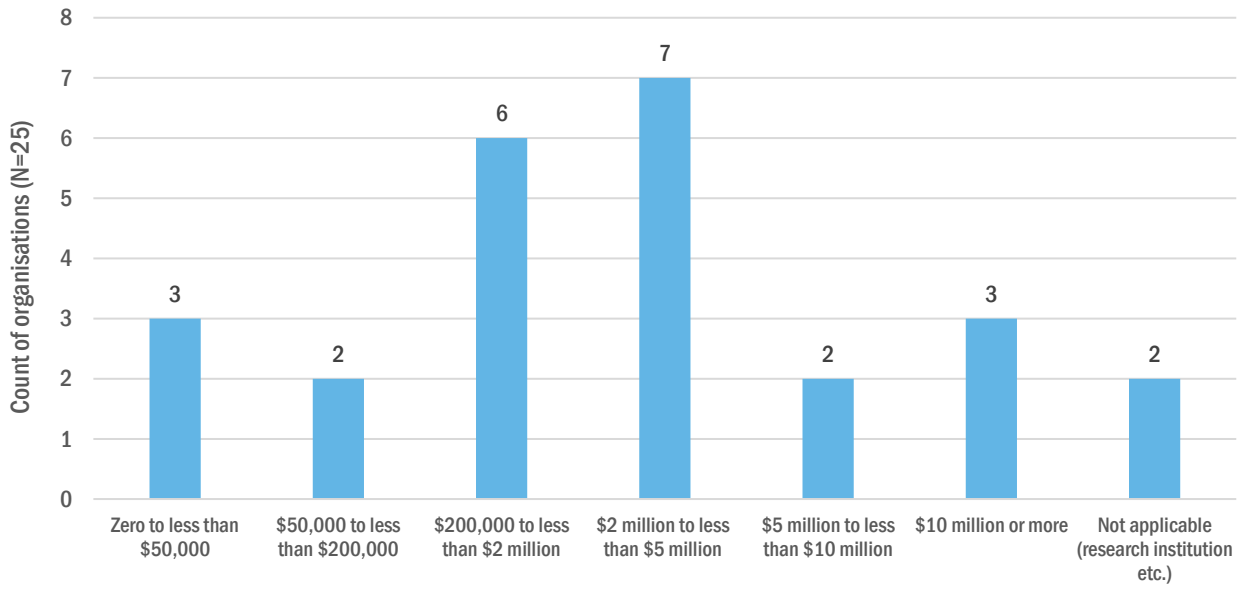
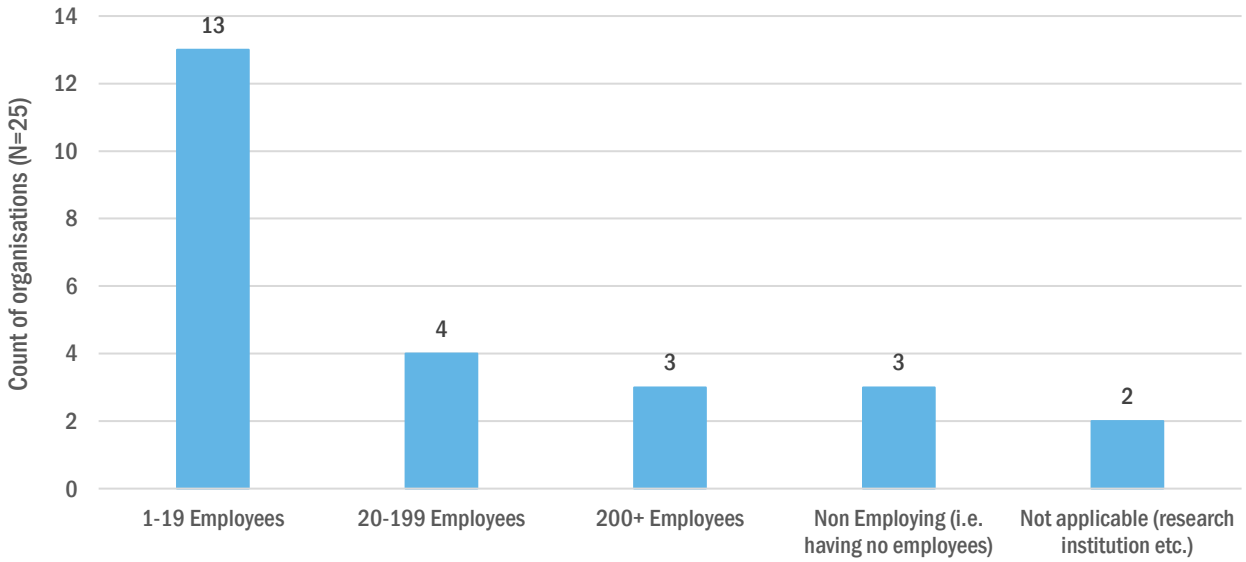


Chart 4.6 Full-time equivalents



Space Operations (8 responses)

As the functional component of the space sector, Space Operations includes the operational requirements for space systems, including launch services (such as those of Rocket Lab) and major space systems, such as satellites. The sub-sector facilitates access to space and the operation of assets in orbit.

The operational requirements for space systems typically consist of one or more earth stations and a space station, and activities involve the transmission and receiving of information to and from earth stations or other space stations using radio communications.

The Space Operations sub-sector in New Zealand, albeit small, is unique. The presence of Rocket Lab highlights the distinct launch service capability that exists in

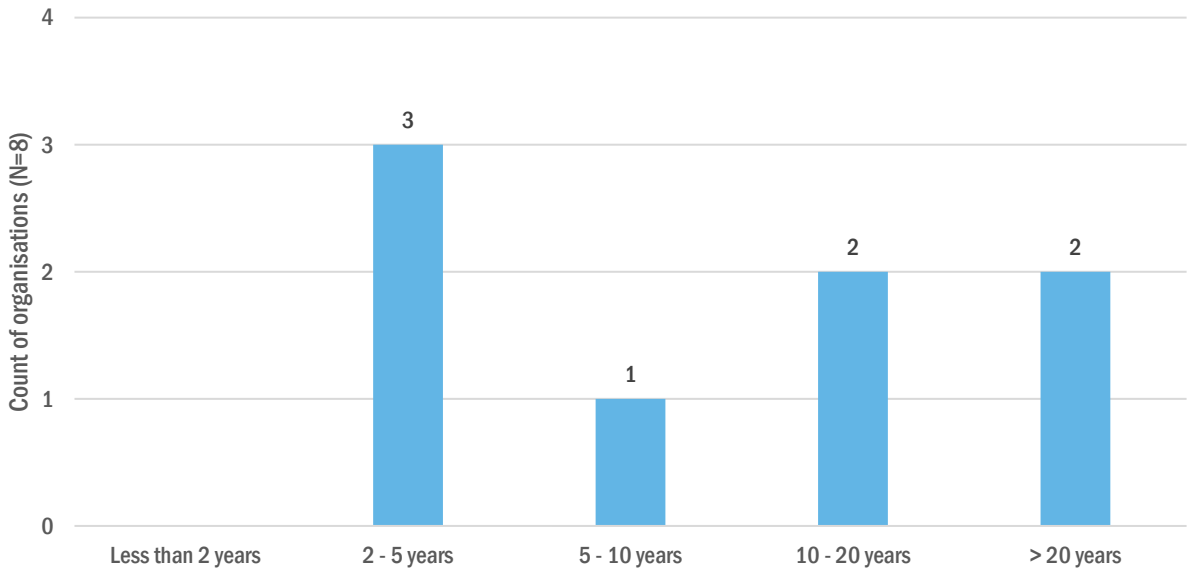
this sub-sector. This is partly due to New Zealand's geographical advantages, with its clear seas and skies and access to a wide range of launch angles.

Organisations operating in this sub-sector are internationally engaged, citing experience with major international space agencies such as NASA and ESA. Organisations work to develop, establish and operate antenna across New Zealand as part of several major global networks.

As explained in the case study in Chapter 2, Rocket Lab is a key example of a participant in Space Operations.

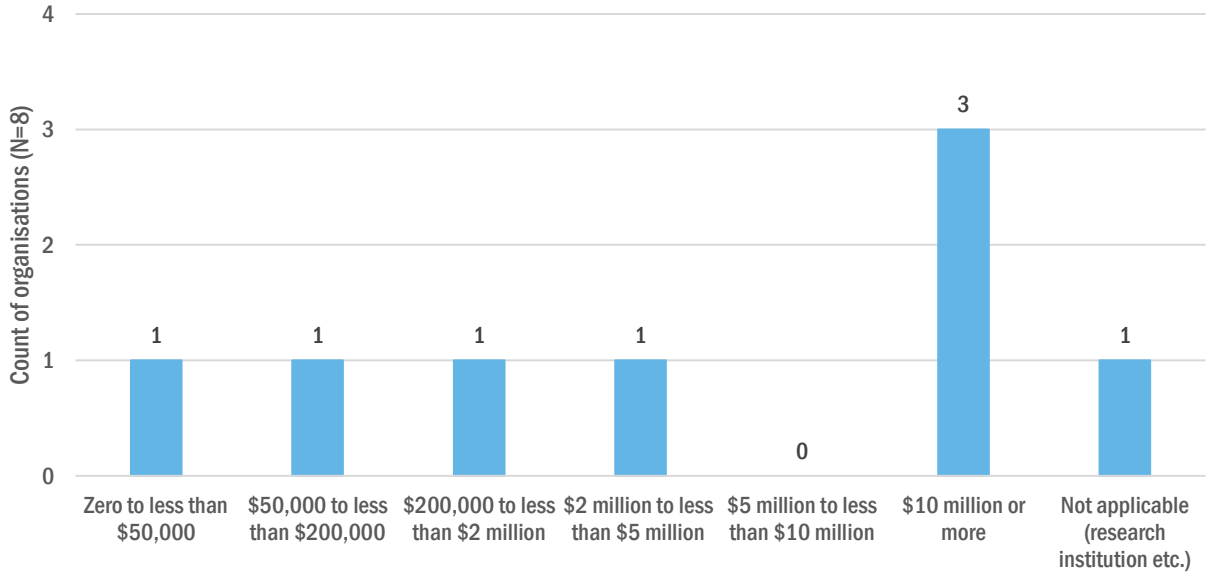
Survey results indicate there is some longevity in the Space Operations sub-sector, with four companies established for longer than 10 years.

Chart 4.7 Duration of operations



Survey results demonstrate this sub-sector has high earning capacity, as evidenced by three organisations reporting turnover of more than $10 million. The key areas of capability nominated by respondents in this sub-sector are concentrated in ground station networks and launch services.

Chart 4.8 Turnover range



Space Applications (29 responses)

The application of space-derived data to non-space activities has driven growth in this sub-sector of the space sector. Individuals and organisations alike are increasingly leveraging data to improve everyday life and boost productivity.

The use of space-derived data to solve industry problems means organisations are more likely to be born out of non-traditional space sectors, rather than the core space sector. This is highlighted by the number of organisations that did not identify space as their primary sector of operation (19); i.e. organisations offering products and services to alternative sectors, rather than exclusively providing to the space sector.

Organisations in this sub-sector are engaged with international public and private actors, with respondents nominating collaboration or engagement with major international space agencies (NASA, ESA, the Japanese Space Agency (JAXA)) as well as with large international companies such as Airbus, SpaceX and Optus.

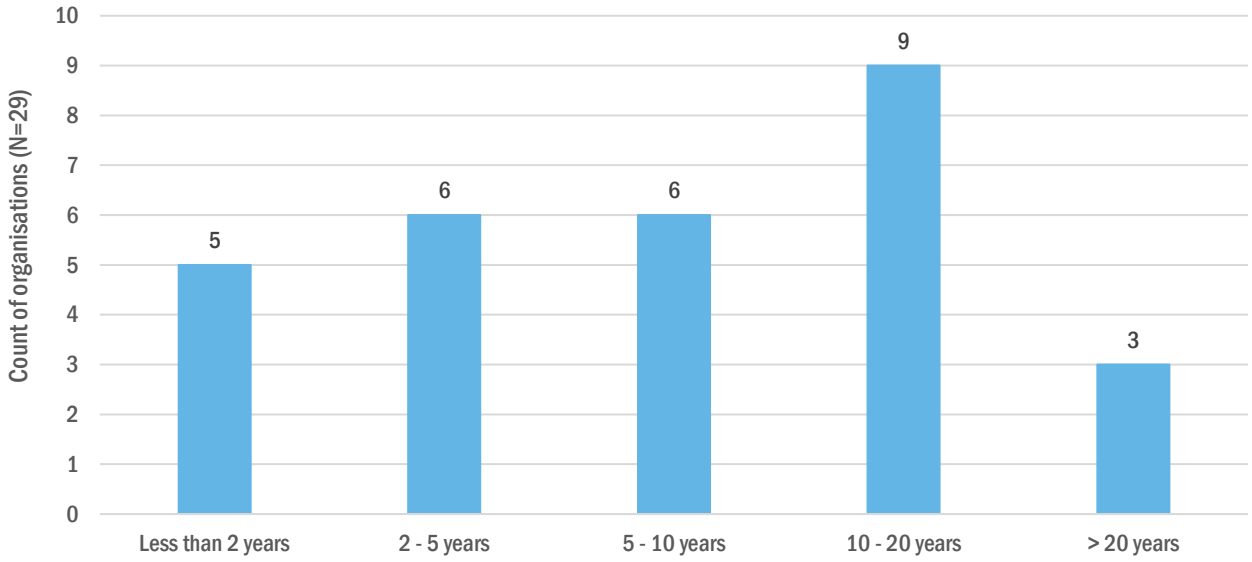
Capability in the Space Applications sub-sector primarily pertains to the following areas:

- Processors of satellite data
- Earth Observation Services & Applications
- Satellite Communications Services Providers.

An example of a Space Applications company is Orbica, based in Christchurch (NZ). The company specialises in the transformation of geospatial data and geospatial artificial intelligence (GeoAI) for the use of decision makers in government and commercial sectors.

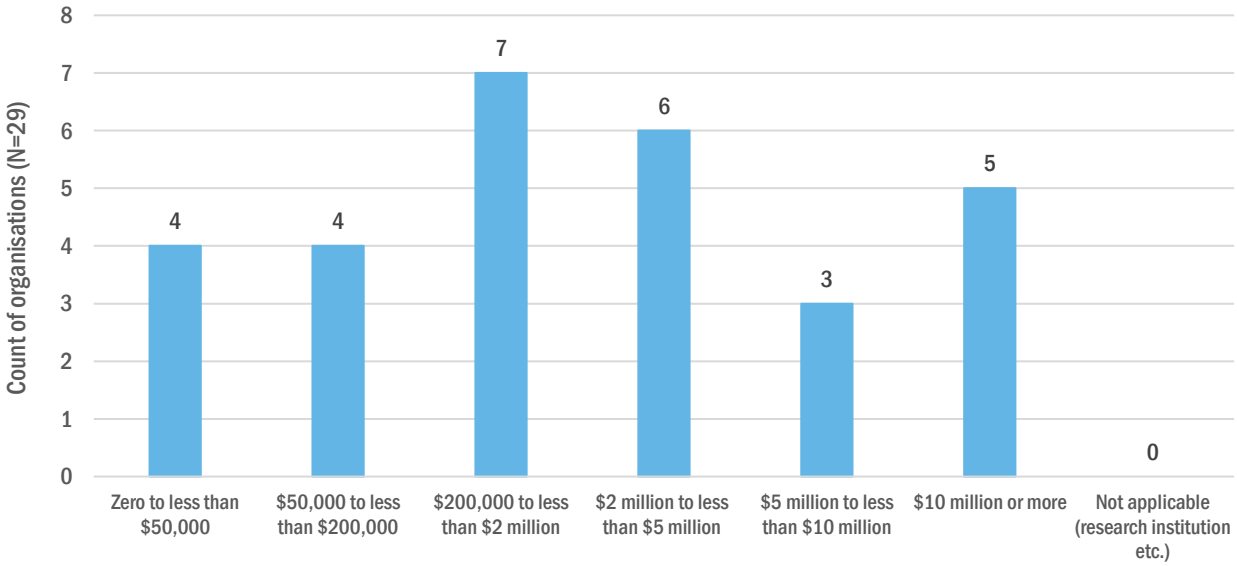
The survey results highlight that the Space Applications sub-sector includes well-established companies; specifically, 9 companies in operation for between 10 and 20 years and three in operation for longer than 20 years. There also exist several newer organisations operating in the sub-sector with 11 companies in operation for 5 years or less.

Chart 4.9 Duration of operations



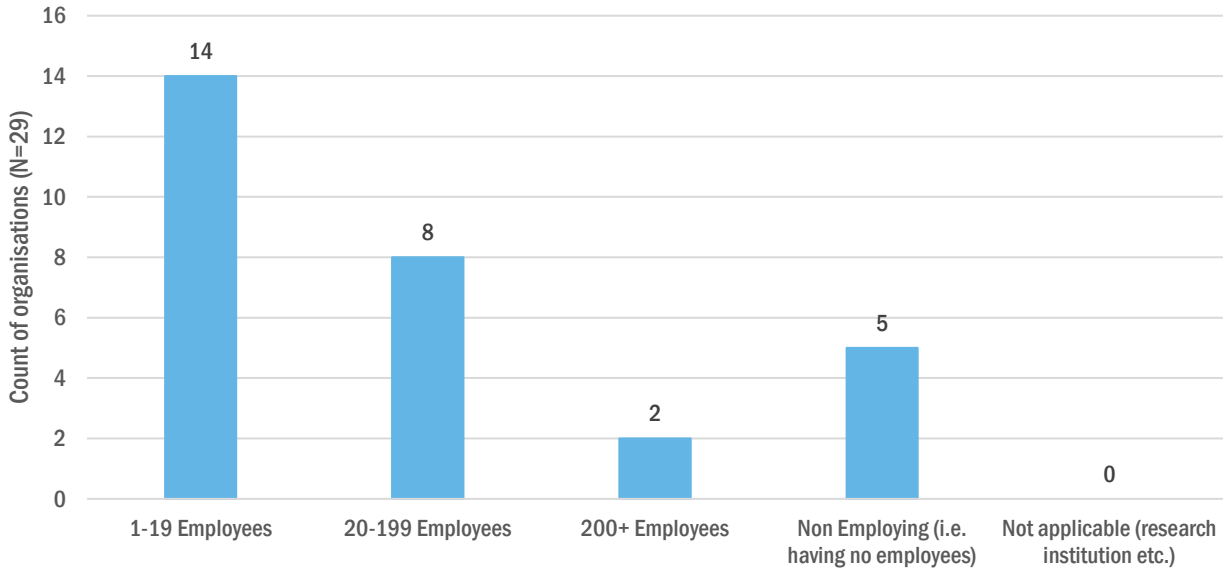
Of all the sub-sectors across the space supply chain, Space Applications has the highest number of companies earning high revenue, with eight companies reporting turnover ranges greater than $5 million. The majority of these, five companies, are earning $10 million or more.

Chart 4.10 Turnover range



The majority of companies are small-medium enterprises, with 14 respondents nominating less than 20 employees. There are also a number of large organisations, with 15 organisations employing more than 20 full-time equivalents.

Chart 4.11 Full-time equivalents



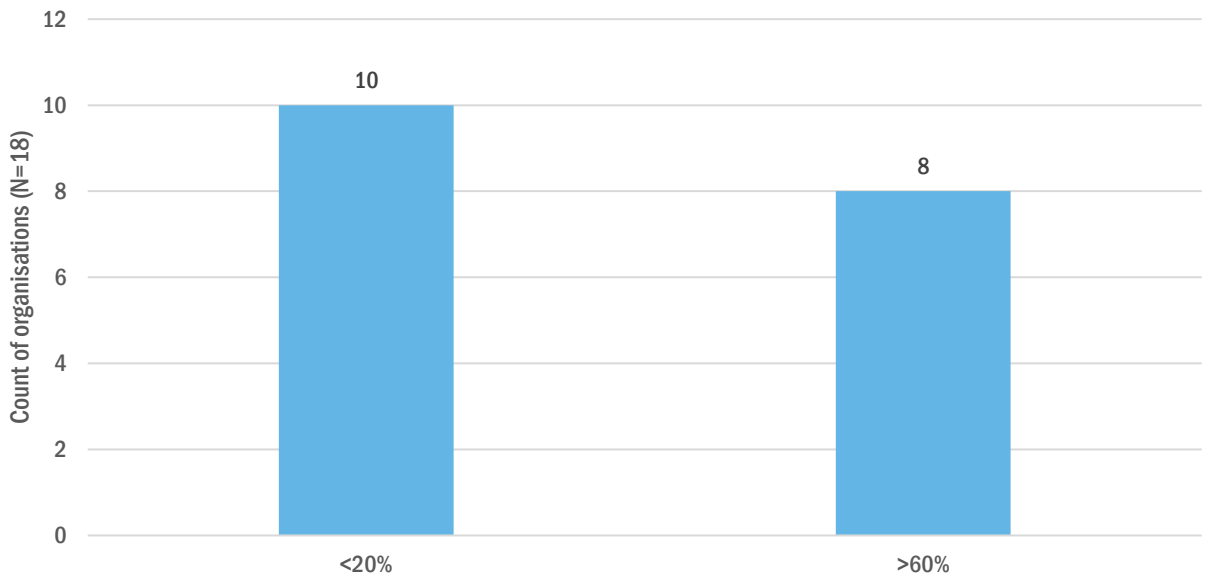
Ancillary Services (18 responses)

Ancillary Services includes organisations working across multiple areas of the economy or providing general operational support. As such, the survey responses of these organisations provide an indication for the way in which the space sector is drawing on other areas of the economy for support. Their role in the space sector includes the facilitation of cross-sector relationship building (particularly into the agricultural sector), innovation and start-up hubs/incubators, the provision of venture capital and consulting, and financial and legal advice.

An example of a participant in Ancillary Services is Webtools. This organisation is based in Christchurch and engages a variety of technology developers across New Zealand, Australia and Europe to provide custom software development and solutions.

Survey responses demonstrate while there are a number of organisations that rely on space-related activities for more than 60% of their revenue, typically organisations do not depend solely on space-related activity. Other areas of the economy where organisations are providing services include construction, finance, insurance and business services and professional, scientific and technical services.

Chart 4.12 Percentage of annual turnover primarily related to space sector activities



Research & Development (15 responses)

Across the space sector, there is deep research and development capability. This capability is crucial to being a competitive participant in the global space sector; redefining frontiers and growing human capital expertise is fostered by the strength of capability located across the supply chain.

Research centres within universities have capability in Space Manufacturing and Space Applications, possessing the large-scale or high-cost infrastructure required to perform industry-leading R&D upon which scientific advancements depend. For example, Auckland University of Technology's Warkworth Radio Astronomical Observatory enables the university to engage globally on several industry-leading research projects. This sort of large-scale infrastructure may attract international expertise.

Government (9 responses)

Government engagement in the New Zealand space sector is multi-faceted.

Survey results revealed that activities in this sub-sector include Government organisations:

- Directly engaging in space-related policy making, regulation and oversight
- Actively contributing to R&D in the space sector
- Using space applications to improve the provision of services.

The data capture exercise identified nine government agencies and organisations engaged in activities related to the space sector.

New Zealand's departmental space budget for 2018-19 was $3.8 million. This funds the operation of the New Zealand Space Agency, regulation and oversight under the Outer Space and High-Altitude Activities Act 2017 and associated business development work.

MBIE spent a further $6.02 million in 2018-19 supporting space science research. This research funding included $3.675m to support the Regional Research Institute Xerra which helps industries access and use space-derived data, through a programme of space science investments partnering with international research institutes and space agencies. This investment is planned to increase in the 2019-2020 financial year.

New Zealand has also been investing in skills and R&D capability including through the establishment of the Space Systems Institute based at the University of Auckland and an agreement with NASA for internships at their Ames Research Centre in California. Government departments and several publicly-funded research institutions contribute to the development and use of space science and technologies across a variety of areas, such as Land Information New Zealand (LINZ).

Government agencies are also users of space-enabled data to fulfil their core objectives such as such as environmental management, monitoring our exclusive economic zone and natural resources, and security and disaster relief.

Part II:

Economic contribution of New Zealand's space sector

5 Economic contribution framework

This chapter explains the model used and various economic factors considered in forming the modelling approach. It also provides an in-depth discussion of the steps followed to extrapolate the survey sample to a representation of the space sector. This includes additions to the sample, adjustments, and data supplementation, where appropriate.

Input-output modelling

Deloitte Access Economics used an in-house input-output model to estimate both the direct and indirect contribution of the space sector. Input-output models are used to model the economic links between industries.

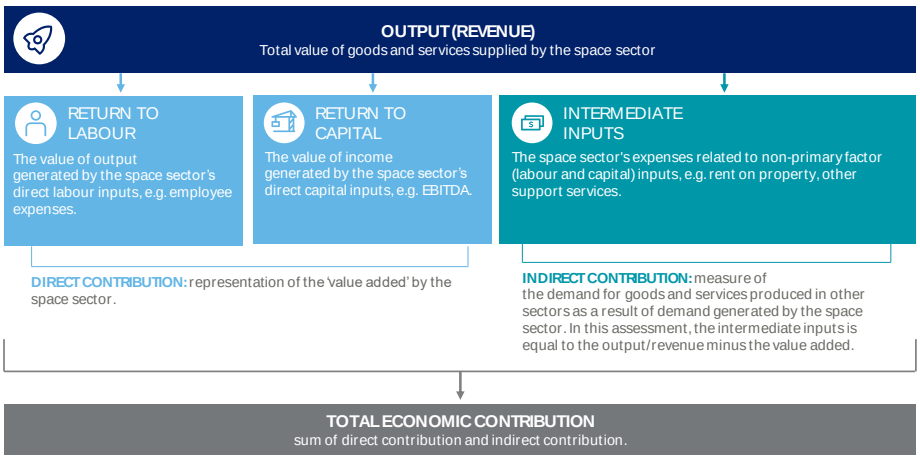
Firstly, estimating the gross output or total revenue of the space sector. Revenue is a useful indicator for the size of a sector, however it does not measure the economic contribution of the space sector.

Secondly, estimating the economic contribution of the space sector. Total economic contribution provides a snapshot of the economic footprint of the space sector and related value-added activities throughout the national economy at a single point in time. Total economic contribution arises from:

- Direct contribution through the space sector's own operations.
- Indirect contribution, through flow-on effects of the space sector's expenditure on intermediate inputs.

The process to estimate the economic contribution is summarised in the diagram below.

Figure 5.1 Visual representation of the process to estimate the economic contribution



Source: Deloitte Access Economics

Direct economic contribution
Direct economic contribution captures the economic activity of the space sector itself, and is measured as the value added by the activities of businesses (i.e. the sum of returns to labour and capital) within the space sector.

The direct contribution is estimated using the income approach to GDP, which sums returns to capital and returns to labour. Returns to capital are calculated through Gross Operating Surplus (GOS), while returns to labour are determined through wages and salaries.

Indirect contribution
The space sector supports wider business activity and service sectors in New Zealand, as reflected in the indirect economic contribution. Indirect economic contribution captures the flow-on effects of the space sector's expenditure on intermediate inputs, and is estimated using Deloitte Access Economics' in-house input-output (IO) model.

The linkages and interdependencies between various sectors of an economy are used to analyse the inputs that represent final demand and flow to other sectors as inputs. Deloitte Access Economics constructed an in-house IO model based on Statistics New Zealand IO tables to estimate the indirect value added.

To address the risk of double counting in assessing the indirect contribution of the space sector as a whole, Deloitte Access Economics developed a weighted index across all the space sub-sectors to capture the intermediate expenditure profile. The approach followed in developing this weighted index is detailed in Appendix D.

The survey response data was used as a primary input

Scaling approach
In estimating both the revenue and the economic contribution of the space sector, Deloitte Access Economics used the survey data as a starting point. However, with a 54% response rate, the survey data provides only a partial representation of the space sector. Deloitte Access Economics implemented a scaling approach to address this shortfall.The scaling approach is only applied in Part II of this report. The scaling approach consists of three steps:

Step 1: Identify and add known commercial participants which did not complete the survey, to their primary sub-sector in the space sector. Examples include Sky TV.

Step 2: Where possible, source publicly available financial data for organisations generating $10 million and more per annum and add the key data points to the revenue and economic contribution analysis.

Step 3: Calculate and apply a scaling factor for each space sub-sector. The scaling factor for each sub-sector was informed by the full distribution list of 220 organisations and the 104 responses to our online survey. Organisations identified as non-commercial, government funded or operated organisations, or tertiary institutes, were removed from the distribution list. The residual 51 non-responding organisations help to determine the appropriate scale-up factor to be applied to each sub-sector. For example, the R&D sub-sector received 15 responses, and two non-responses. In this case, a scaling factor of 12% was applied.

Attributing revenue and employment to space-related activities
In estimating space revenue and economic contribution, it is essential to only account for the revenue and economic contribution related to space. For example, a manufacturing company may be involved in activities other than space-related activities.

For this reason, Deloitte Access Economics calculated the revenue and FTEs attributed to space activities. In the online survey respondents were asked "*What percentage of your annual turnover range would you classify as primarily related to space economy activities in FY18*". Based on the survey responses, the average proportion of revenue and FTEs attributable to space for each sub-sector was calculated.

Refer to Appendix D for a more detailed explanation of the modelling inputs and assumptions used to assess the economic contribution of New Zealand's space sector.

Economics of the space sector

For the purposes of this analysis, an economic perspective of the space sector has been developed to ensure the contribution to the broader New Zealand economy can be understood.

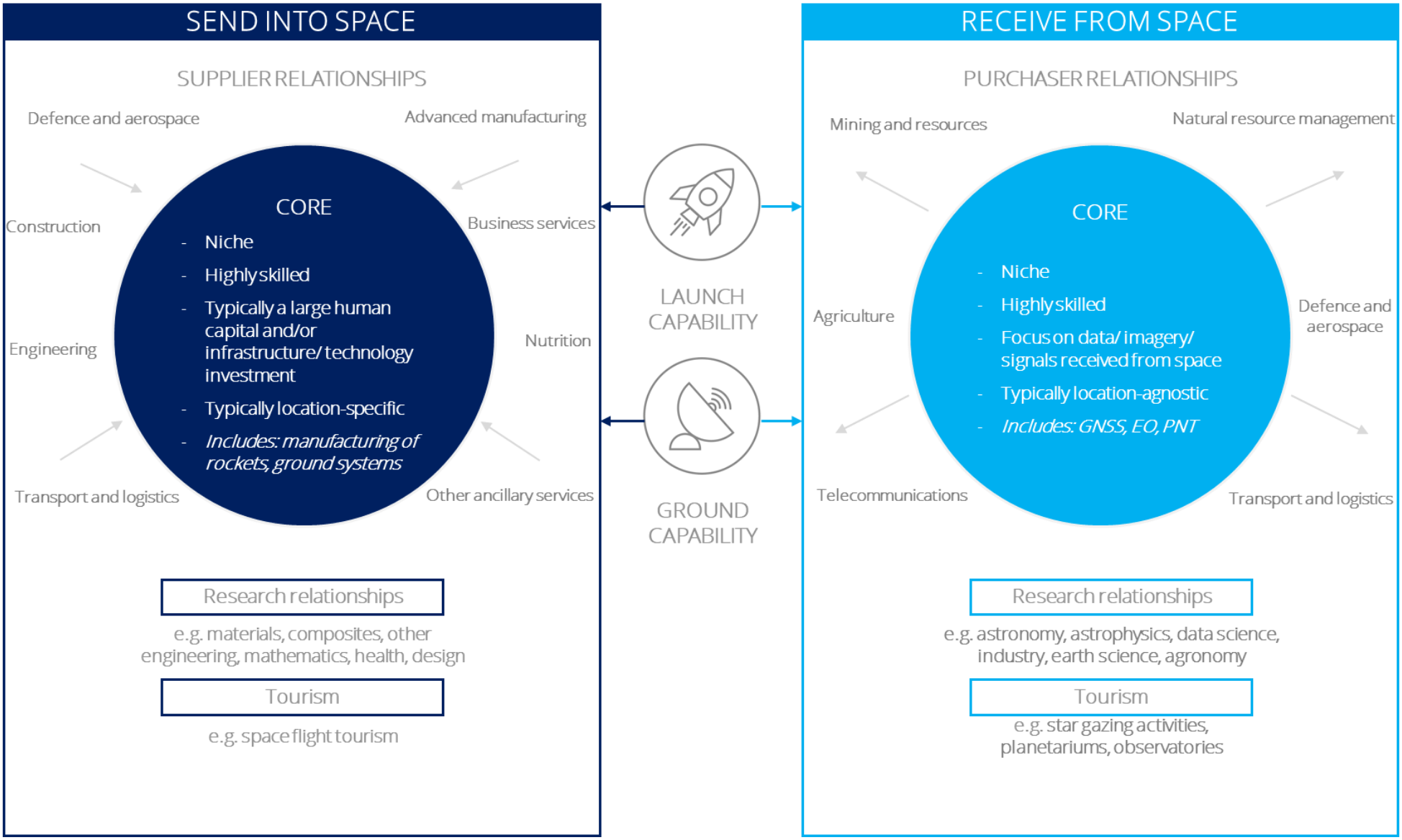
This analysis explains the interactions between New Zealand's space sector and the wider economy from an economist's perspective and specifically, how it **draws in resources** from the broader economy. Analysis of the space sector in this way informs the economic contribution methodology, **assessing the linkages** between the space sector and the wider economy.

Figure 5.2 overleaf depicts the two distinct, but interlinked, components of the space sector, building on Figure 3.1 on page 16:

- First, there is the part of the space sector that **sends objects into space**. In the New Zealand context, this particularly refers to Space Manufacturing.
    - This core is extremely niche and requires highly skilled workers and, typically, sizeable capital investments. Due to the nature of the goods and services produced, this component is relatively location-specific, meaning that once this core is established (through capital, know-how and technological investments), it is more likely to be fixed in location over the short-to-medium-term.
    - The supply chain impacts for this part of the space sector are currently focused on the upstream industries – that is, the suppliers of inputs into the core, such as advanced manufacturing.
    - The research in this part of the space sector focuses on areas such as materials and composites, mathematics, and aeronautical engineering.
- Second, the part of the space sector that **receives data from space** refers specifically to Global Navigation Satellite Systems (GNSS), Earth Observation (EO) and Position Navigation Timing (PNT). This part of the sector corresponds to the space applications category in Figure 3.1.
    - This core is also highly niche, with specialist skills in data, imagery and signals analysis. The outputs of this core can be supplied from anywhere in the world with a data cable.
    - The supply chain impacts for this part of the space sector are in the downstream industries that purchase the outputs of the core, such as agriculture.
    - The research in this part of the supply chain focuses on areas such as astrophysics and astronomy.

The crucial link between the two perspectives (sending into space or receiving from space) is launch and/or ground system capability. These correspond to the space operations category in Figure 3.1. For value to be realised, whether it be supplier/customer relationships or upstream/downstream activities; launch or ground system capability and infrastructure is integral. Capability or activity in these areas act as catalysts to growth in the space sector.

Figure 5.2 An economic perspective of the space sector



Source: Deloitte Access Economics

6 Estimated economic contribution

This chapter examines the economic contribution of New Zealand's space sector. The total economic contribution of the country's space sector can be disaggregated into the sum of direct and indirect components.

As such, the chapter is presented as follows:

- Summary of economic contribution results
- Gross output (revenue) of New Zealan's space sector
- Direct and indirect economic contribution (including employment)
- A sense check of the results.

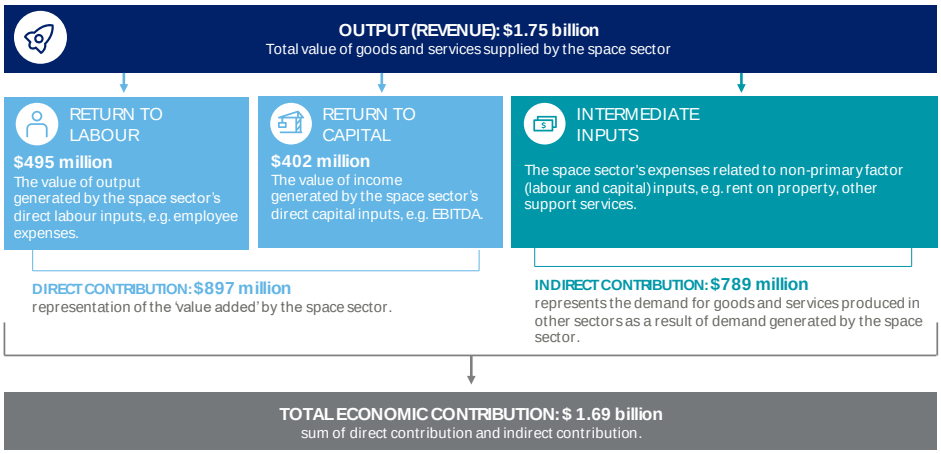
A full methodological discussion can be found in Appendix D and Appendix E.

Summary of results

Following the approach explained in Chapter 5, Deloitte Access Economics has estimated:

- Total revenue or gross output of the space sector to be $1.75 billion. This represents 0.5% of New Zealand's total gross output, and 0.27% of the global space sector(by revenue).
- Total economic contribution to be $1.69 billion, where:
    - The direct contribution is $897 million, in value-added terms to the economy.
    - The indirect contribution, reflecting expenditure on intermediate inputs such as transport services and financial services, is $789 million in value-added terms.
- The space sector supports 5,000 full-time equivalent roles ('FTE') across all space sub-sectors, equivalent to 0.2% of the total workforce in New Zealand. The space sector indirectly supports approximately 7,000 FTE positions in industries that provide services to the space sector (indirect FTE).

Figure 6.1 Visual representation of economic contribution estimates



Source: Deloitte Access Economics

The gross output (or revenue) of New Zealand's space sector

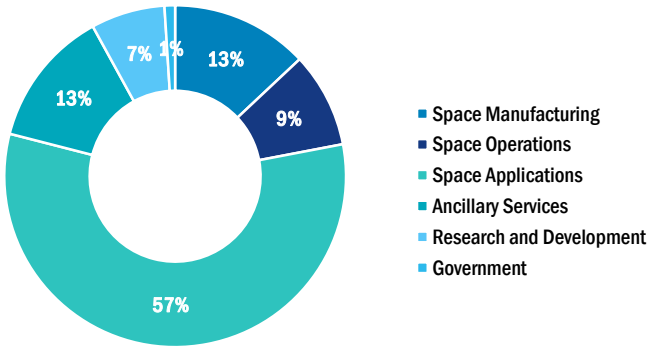
Deloitte Access Economics estimates the **total revenue of New Zealand's space sector is $1.75 billion (in 2019 dollars).** The estimated revenue for each sub-sector is presented below.

Table 6.2 New Zealand space sector revenue by sub-sector

Sub-sector	NZD millions (2019 dollars)	Proportion of total revenue (%)
Space Manufacturing	247	13%
Space Operations	150	9%
Space Applications	1,007	57%
Ancillary Services	221	13%
Research and Development	119	7%
Government	10	1%
Total	**1,754**	**100%**

Source: Deloitte Access Economics

Chart 6.1 Turnover range



Source: Deloitte Access Economics

These results align with the survey analysis in Chapter 4. The space sector is dominated by Space Applications (57%), followed by Space Manufacturing (13%) and Ancillary Services (13%). With reference to the London Economics report for the UK Space Agency, this revenue structure of the space sector is similar to other international studies.

Estimated revenue does not include New Zealand's government budget for the space sector. The reason for this is commercial revenue was used as a basis to assess the economic contribution.

Direct and indirect economic contribution

The space sector has an important role to play in New Zealand's economy in terms of its contribution to GDP and employment.

Deloitte Access Economics found the space sector contributed **$1.69 billion** to the New Zealand economy in 2018-19.The space sector contribution consists of:

- **Direct contribution of $897 million**, in value-added terms to the economy.

- **Indirect contribution**, reflecting expenditure on intermediate inputs such as transport services or financial services, is **$789 million** in value-added terms.

Table 6.3 Total economic contribution of space sector, 2018-19 ($ millions)

	Direct	Indirect	Total
Value added	**897**	**789**	**1,686**
- Labour income	495	365	860
- Gross operating surplus	402	424	826

Source: Deloitte Access Economics

The direct contribution of the space sector comprises $495 million in wages and $402 million in gross operating surplus. The total direct contribution is 51% of the total revenue of $1.75 billion earned by the space sector. Typically, in economic modelling, direct contribution of a sector is close to 50% of revenue, so the result is not inconsistent with expectations.

The indirect contribution is $789 million. This illustrates the space sector's significant role in supporting activity in other sectors of the economy, and that its indirect contribution is almost as high as the direct economic contribution.

Direct and indirect employment

Like many developed nations, the increasing pace of technological change and its associated risk of disruption are central to future workforce planning initiatives. As such, embracing and nurturing high-tech industries will allow for more job creation, providing opportunities for displaced workers in other industries and future-proofing the economy. In 2018-19, the space sector supports approximately **12,000** FTEs:

- The space sector directly employs about than 5,000 FTEs.
- The space sector supports about 7,000 FTEs in other sectors that provide services to the space sector.

Direct employment captures those who are employed by the space sector, such as Space Manufacturing, and indirect employment captures employment for those companies that supply inputs to the companies in the space sector. For example, employment in companies providing transport services and financial services would be captured as indirect employment for space sector activities.

For comparison the direct employment of New Zealand's space sector represents about 10% of the total current employment in the advanced manufacturing sector or 0.2% of the total workforce in New Zealand.

While for every 100 FTE jobs created by the space sector, 140 FTE jobs are supported indirectly by New Zealand's space sector.

Economic contribution by sub-sector

Space Applications makes the largest contribution to the New Zealand economy out of the sub-sectors. It contributes 44% of the total direct contribution to the space sector. The second largest contributor is Space Operations (22%). This is followed by Space Manufacturing (18%), Ancillary Services (9%) and Research and Development (7%).

The magnitude of labour cost (wages) present for Space Operations is a key driver of its relatively large contribution. This cost is considered high when compared to the sub-sector gross output (revenue).

Table 6.4 A breakdown of the direct contribution by sub-sector

Sub-sector	Direct contribution (NZD millions, 2018-19)	Proportion of the direct contribution (%)
Space manufacturing	160	18%
Space operations	200	22%
Space applications	398	44%
Ancillary services	78	9%
Research and development	61	7%
Total	**897**	**100%**

Source: Deloitte Access Economics

Deloitte Access Economics developed a weighted index for the space sector as a whole to assess the indirect contribution. For this reason the estimated indirect contribution cannot be attributed to a specific space sub-sector.

The table below illustrates the direct employment contribution by sub-sector. Similar to the survey data and analysis, the workforce in the space sector is dominated by Space Manufacturing, Space Operations and Space Applications. Further, while Space Applications is dominant in its share in revenue (57%) and direct contribution (44%), it is less so in the number of FTE jobs supported in the New Zealand economy.

Table 6.5 New Zealand space sector direct contribution to FTE jobs by sub-sector

Sub-sector	FTE jobs	Proportion of FTE jobs (%)
Space Manufacturing	1,417	28%
Space Operations	1,223	24%
Space Applications	1,579	32%
Ancillary Services	415	8%
Research and Development	415	8%
Total	**5,048**	**100%**

Source: Deloitte Access Economics

A sense check

This is the first time a study such as this has been undertaken in New Zealand, and many are still only beginning to obtain a clear understanding of the space sector more broadly. A certain degree of conservatism is required to ensure that these estimates fall within a realistic range. With this in mind, Deloitte Access Economics performed a number of crosschecks between the estimate of total revenue found in this report and alternative market-sizing proxies.

The market-sizing proxies are calculated by taking an estimate of the global space sector and working downward, using appropriate benchmarks to determine New Zealand's relative share. In this exercise Deloitte Access Economics considered what the implied value of New Zealand's space sector would be if:

- The assumed that the market share of the respective proxy is a reasonable approximation of New Zealand's contribution to global space activities;
- We apply the estimated market share to the value estimate for the global space sector. The total global space sector was estimated to be NZD $647 billion in 2019.

The inherent complexity of the global space environment means it is difficult to select an appropriate measure against which to compare New Zealand's space sector. However, proxies were selected based on data availability, transparency of the proxy and relatability to the space sector, where possible.

The three proxies and their implied revenue estimates are presented in Table 6.4. The table shows that Deloitte Access Economics' revenue estimate for New Zealand's space sector of NZD $1.75 billion falls within the same range as estimates based on the proxies - NZD $1.4 billion to $3.1 billion.

Table 6.6 Proxy summary

Proxy	Approach	Limitations	New Zealand's assumed share of the global space sector	Estimated total revenue of the space sector
Share of international trade	New Zealand's share of world trade is approximately 0.2%. Furthermore, New Zealand's third largest export sector is advanced manufacturing, which is a core capability of a strong space sector. Given these features, a simple of estimate of New Zealand's share of total world trade was used to calculate New Zealand's implied contribution to the value of the global space sector.	A key assumption – that New Zealand's share of the global space sector is proportional to its share in world trade – also introduces a number of limitations. Important factors that may influence the relative share of total space trade include: • Competitive advantages • The amount of government support available • Trade relationships, diplomatic arrangements, and defence agreements.	0.21%	**$1.4 billion**
Share of international launch activities	Launch activities are a significant sub-sector within the global space sector and may provide an indication as to the relative strength of a country's space sector. In 2018, the global value of commercial orbital launch services was estimated to be USD $6.2 billion. This value comprised 93 satellite launches, of which three were launched from New Zealand by Rocket Lab. At an estimated USD $10 million per launch, three New Zealand launches account for a total of USD $30 million. Using this estimate, it is possible to calculate a proportion of global launch activities and generalise the result to the entire space sector.	In addition to assuming a country's launch activities are proportionate to its total space activities, other inherent limitations of this approach include: • Heavy and small launches have different cost structures, as do sub-orbital launches. • Rocket Lab's launch cadence is increasing	0.48%	**$3.1 billion**
Share of international space-related scientific publications	Insofar as innovation is the end product of research and development, and this research is publically available, the number of space-related scientific publications can indicate the underlying level of space innovation within a country. OECD statistics were used to determine the proportion of global space-related scientific publications attributable to New Zealand authors and generalise this once again to the value for the global space sector.	Scientific publications do not necessarily imply commercial activity. Indeed, countries with strong funding and capital networks may be better at commercialising their research than others. In this sense, even space-related patent or design counts may not provide an accurate estimation of commercial space revenues. Furthermore, space-related scientific research is often embargoed for national security reasons or conducted privately within companies. The maturity lag between the private research stage and when it is published and/or patented will underestimate the contribution of new entrants to the global space sector.	0.3%	**$1.9 billion**

Source: Deloitte Access Economics

7 References

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Appendix A Survey Methodology

To better understand the scope of New Zealand's space sector, Deloitte Access Economics undertook a thorough data capture exercise. Organisations identified by Deloitte Access Economics as being engaged in the space sector (as defined in Chapter 3) were contacted and asked to participate in this exercise.

Distribution list and survey responses
To compile a list of organisations, Deloitte Access Economics conducted extensive desktop research, and engaged with existing industry associations and known organisations active in New Zealand's space sector. This research informed the development of a distribution list of 220 organisations. All organisations on this list were sent the survey.

There were 119 unique responses to the survey, which were then subject to data validation. From the 119 responses, 104 responses have been assessed as suitable for analysis. All data included in this report has been aggregated and de-identified to maintain the confidentiality of the operations of New Zealand organisations.

Organisations who offered to distribute the survey to their networks are listed below.

Name
Spacebase
Christchurch Aerospace
Christchurch New Zealand
Agritech New Zealand
Xerra
KEA Global
Callaghan Innovation
Wellington Space Meet-up
Royal Astronomical Society
Uniservices
Business New Zealand
Infrastructure New Zealand
Astrobiology New Zealand
Telecommunications Users Association New Zealand (TUANZ)
Gravity Law
New Zealand Trade & Enterprise
Skybase
Orbica
Fabrum Solutions
Great South

Data capture

To develop a directory of New Zealand's space sector, Deloitte Access Economics distributed a bespoke data capture instrument which asked respondents questions such as:

- Turnover range
- Number of full-time equivalent roles
- Duration of operation
- Level of engagement in the space sector
- Other industries of operation
- Research and development expenditure
- Space sectorsupply chain classification and key capability areas.

The instrument (for completion online) was distributed to organisations in the space sector via email and remained open for completion over a 4 week period from 01 July 2019 to 03 August 2019. The survey instrument questions are detailed in Appendix F of this report.

Data validation

To ensure the integrity of New Zealand's space sector directory, Deloitte Access Economics undertook a manual data validation exercise to ensure the quality of the dataset for analysis. As part of this process, Deloitte Access Economics check for:

- Coherence and comparability
    - For example, this included checking for the duplication of responses (where multiple responses from the same organisation were received). In the context of this data capture exercise, this occurred for university organisations where multiple areas of the university are engaged in space-related activity or education and training activities that build the key capability areas for the space sector.
- Clarity and accessibility
    - For example, this included checking for the appropriateness of responses. Such as assessing the degree of completeness of responses (where organisations would not complete survey questions sufficiently to provide meaningful analysis).
    - This also included validating organisations.

Primary sub-sector reclassification

As part of the data capture exercise, organisations were requested to classify their space-related activities across the supply chain. Organisations were able to classify capabilities across multiple areas, which were then analysed to identify a *primary* sub-sector of operational capability.

Appendix B Survey Results

This section summarises the survey results for *all* respondents across the key questions.

Chart B.1 Organisation Type

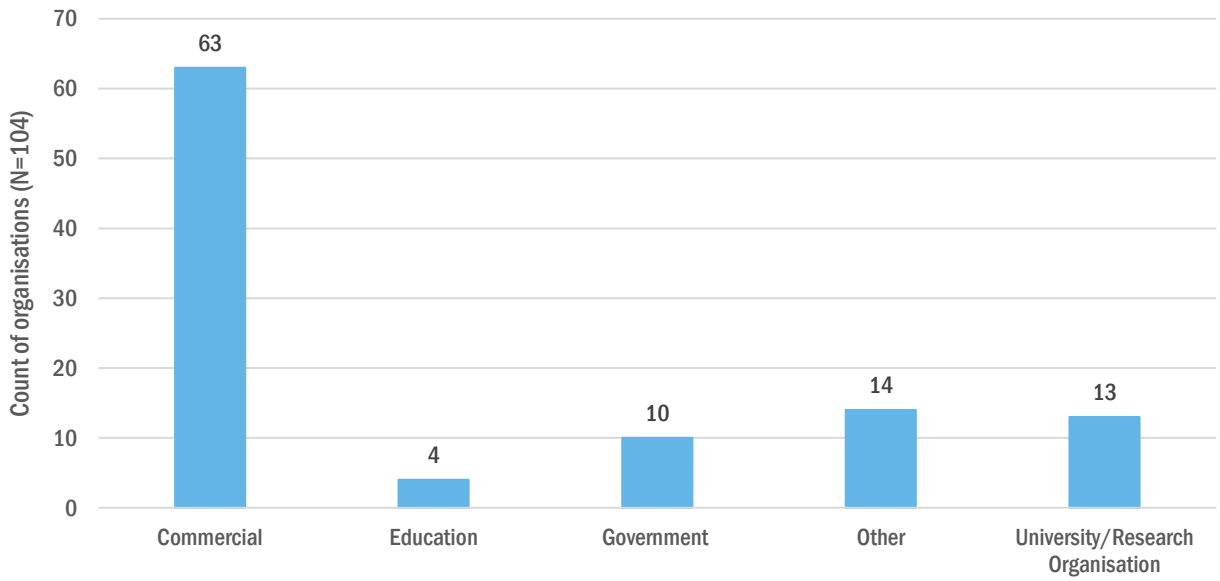


Chart B.2 Turnover range

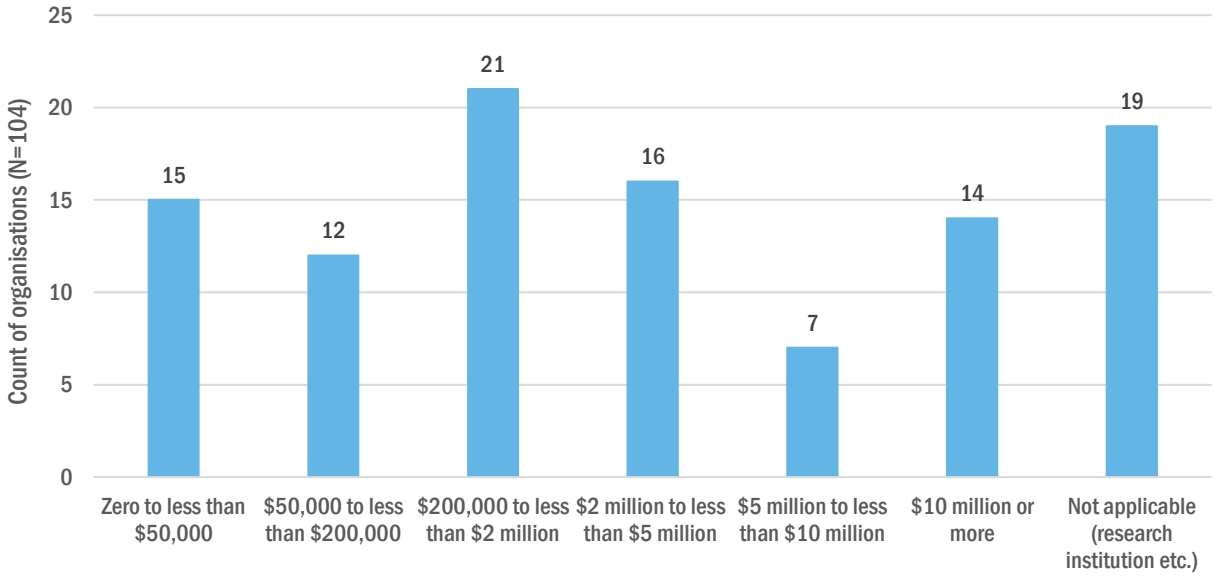


Chart B.3 FTEs

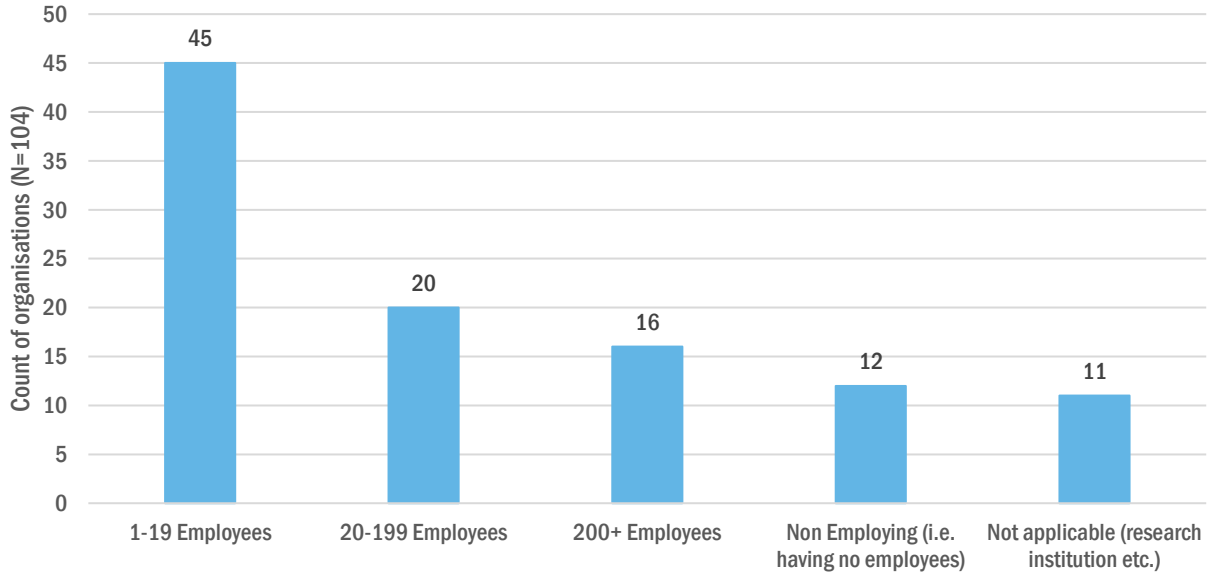


Chart B.4 Duration of operations

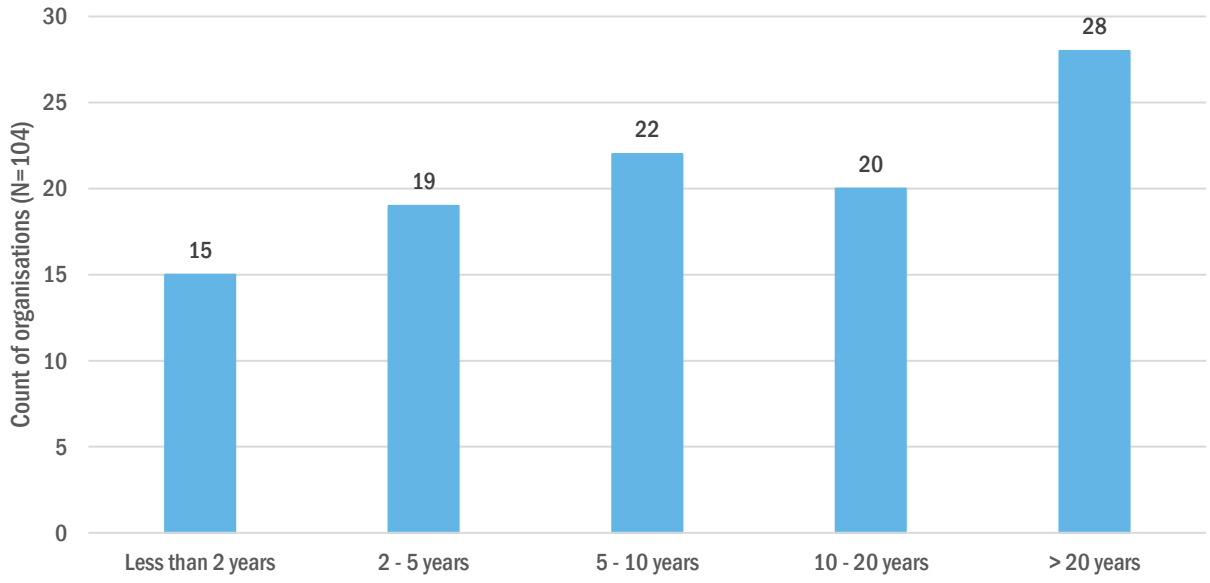


Chart B.5 Space is primary industry of operation

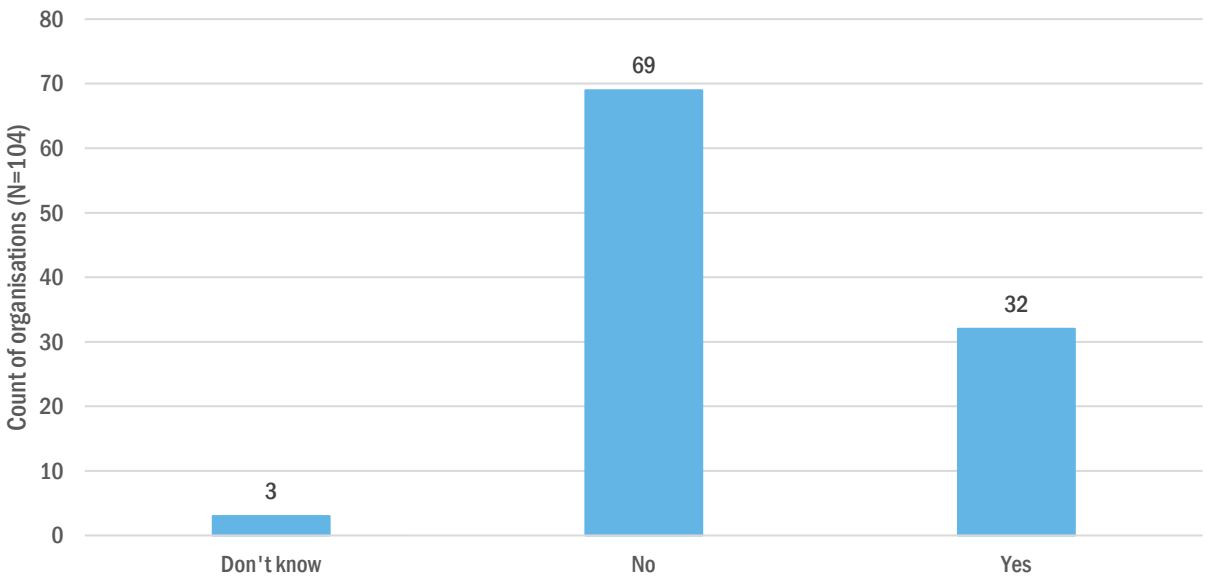


Chart B.6 Percentage of turnover related to space

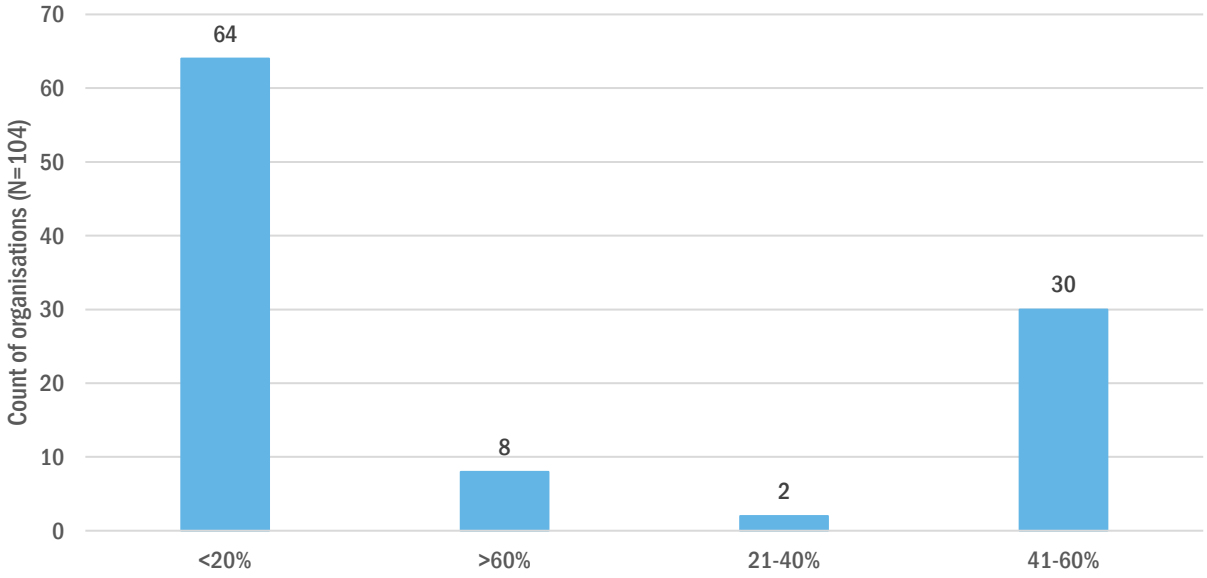


Chart B.7 Value of export activities from space sector activities

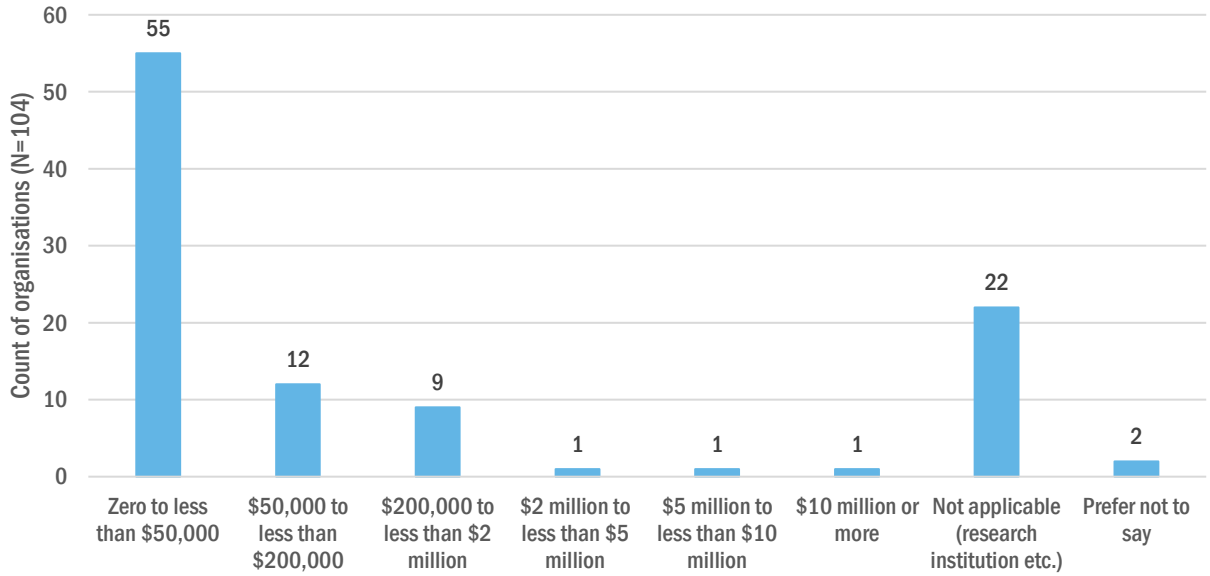


Chart B.8 Alternative industry of operation

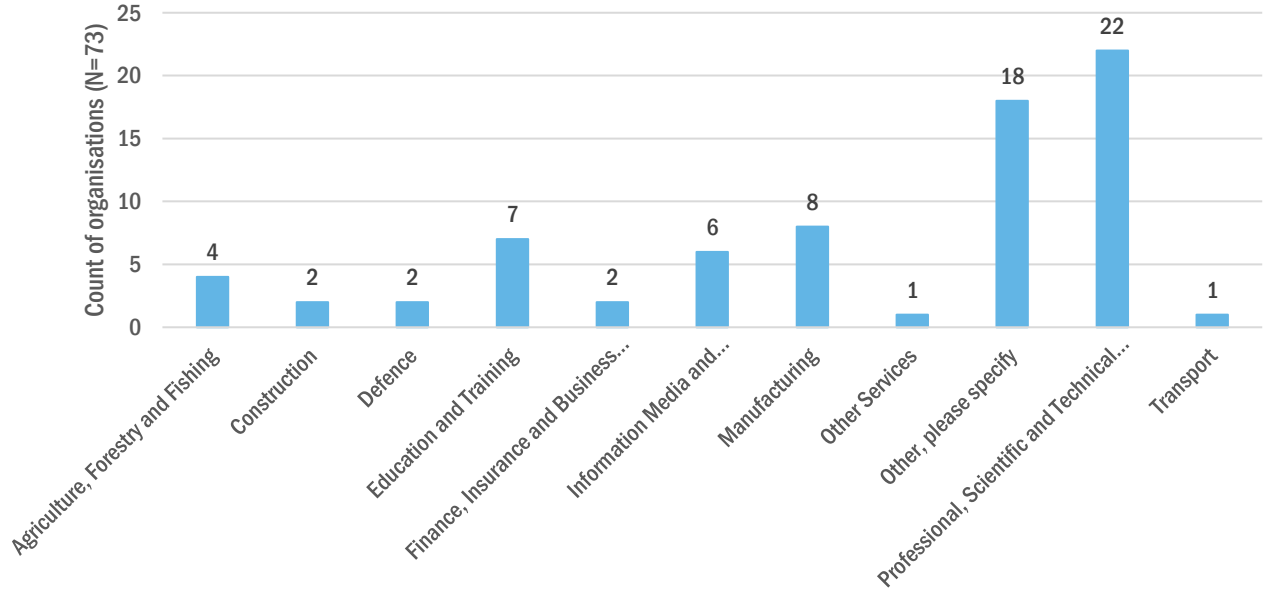
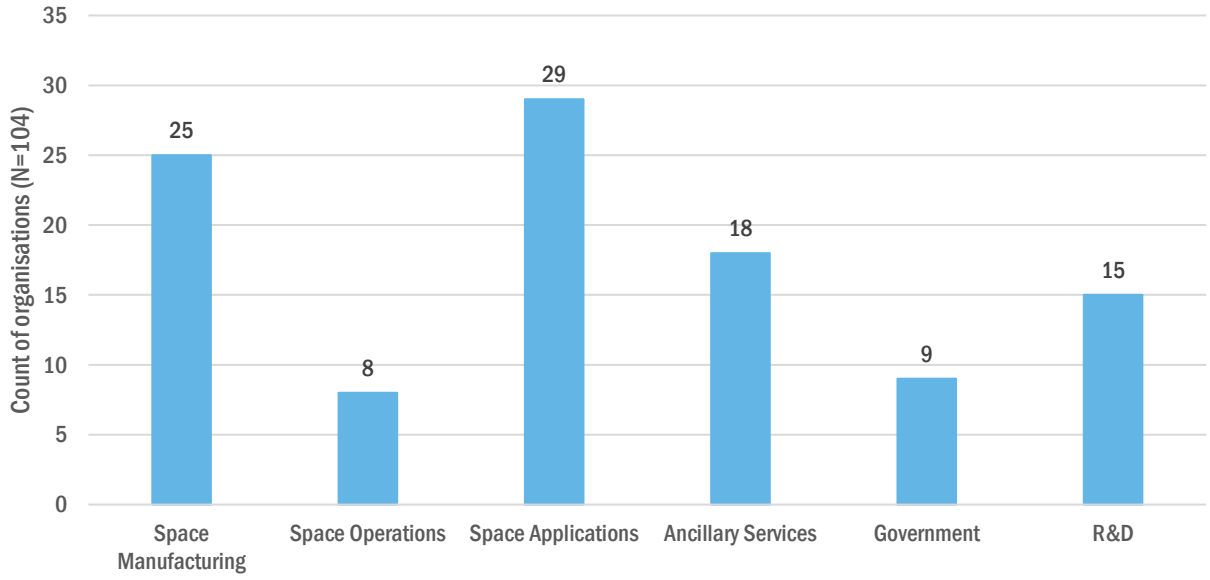


Chart B.9 Primary sub-sector of operation



Appendix C Sub-sector survey results

The following section provides highlights of survey results by sub-sector.

Space Manufacturing

Chart C.1 Duration of operations

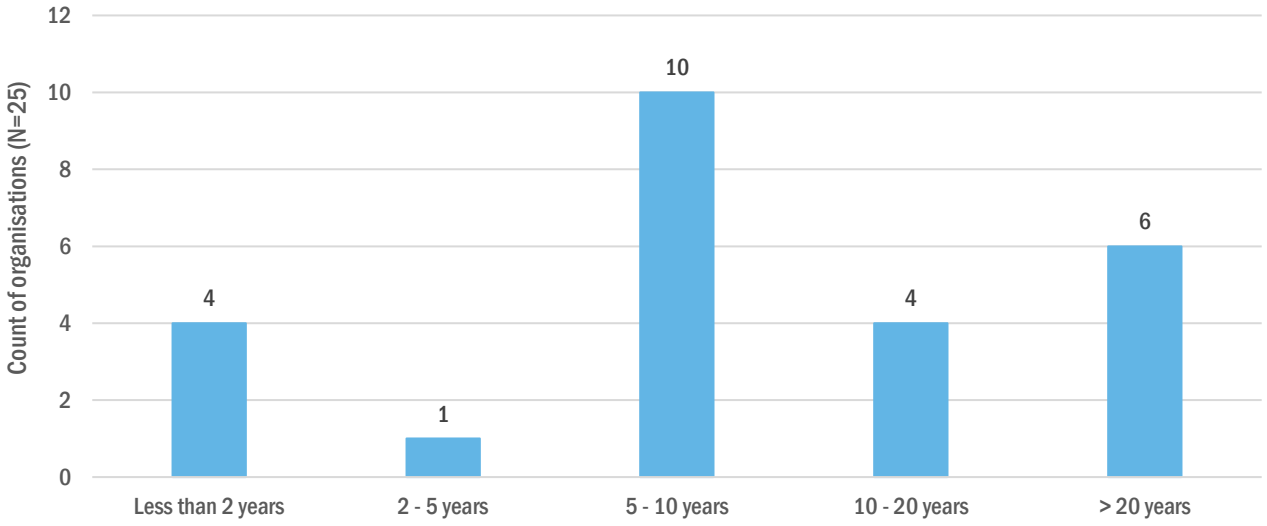


Chart C.2 Turnover range

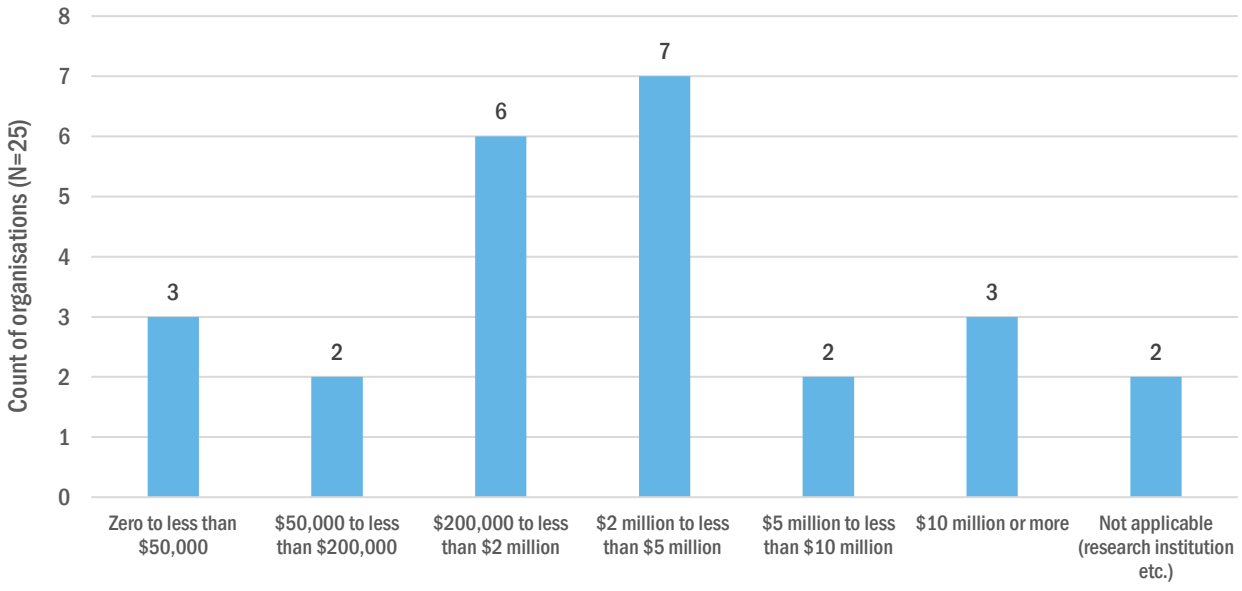


Chart C.3 FTEs

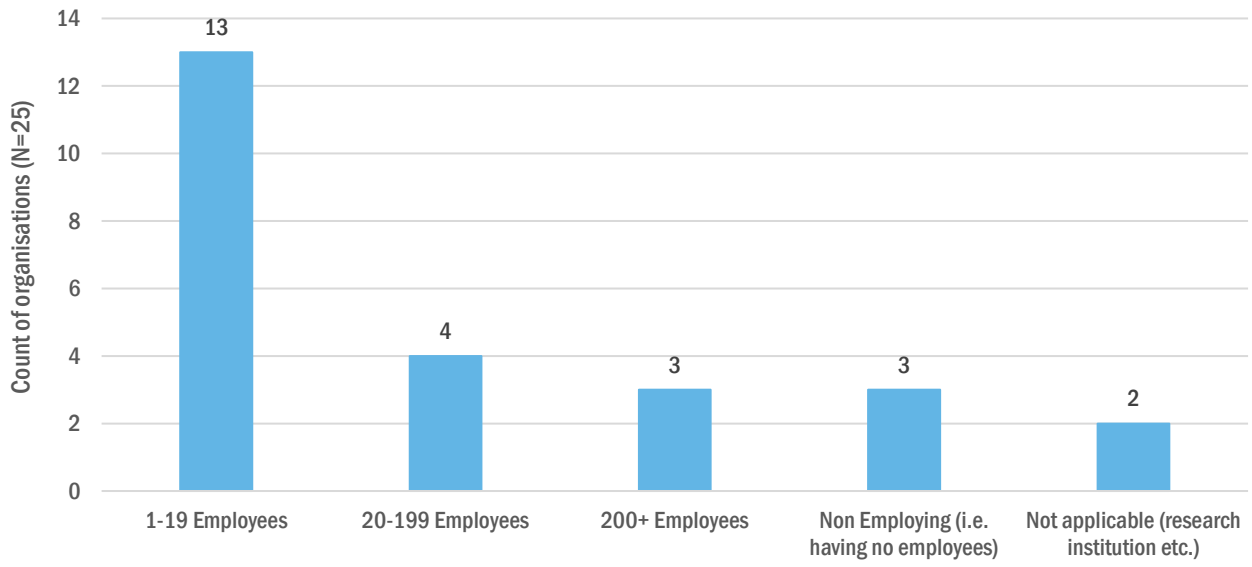
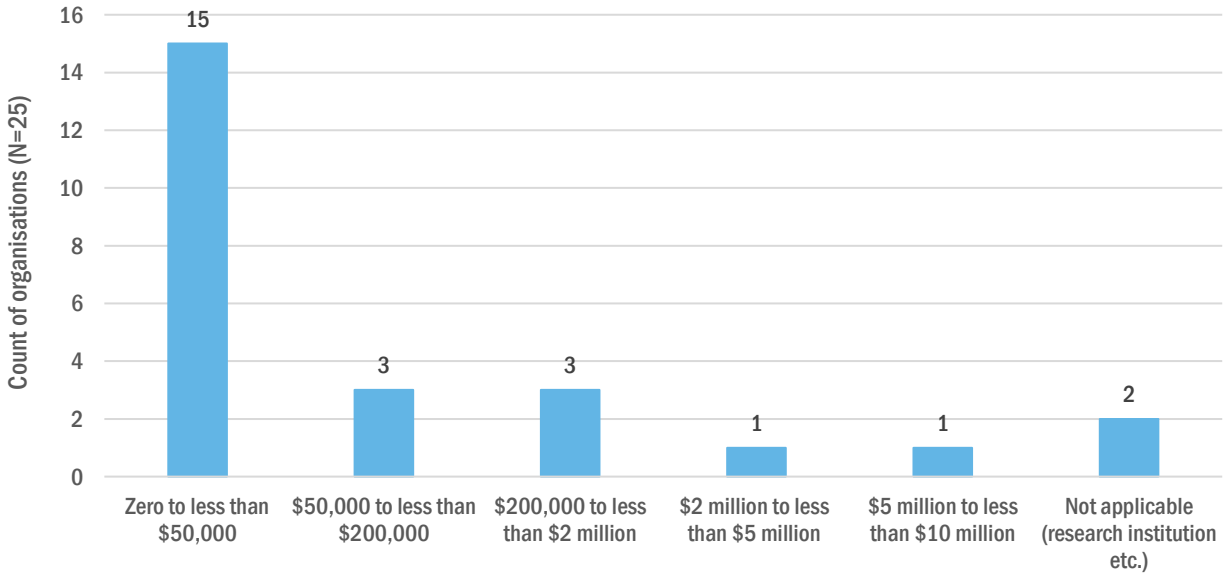


Chart C.4 Value of exports from space activities



Space Operations

Chart C.5 Duration of operations

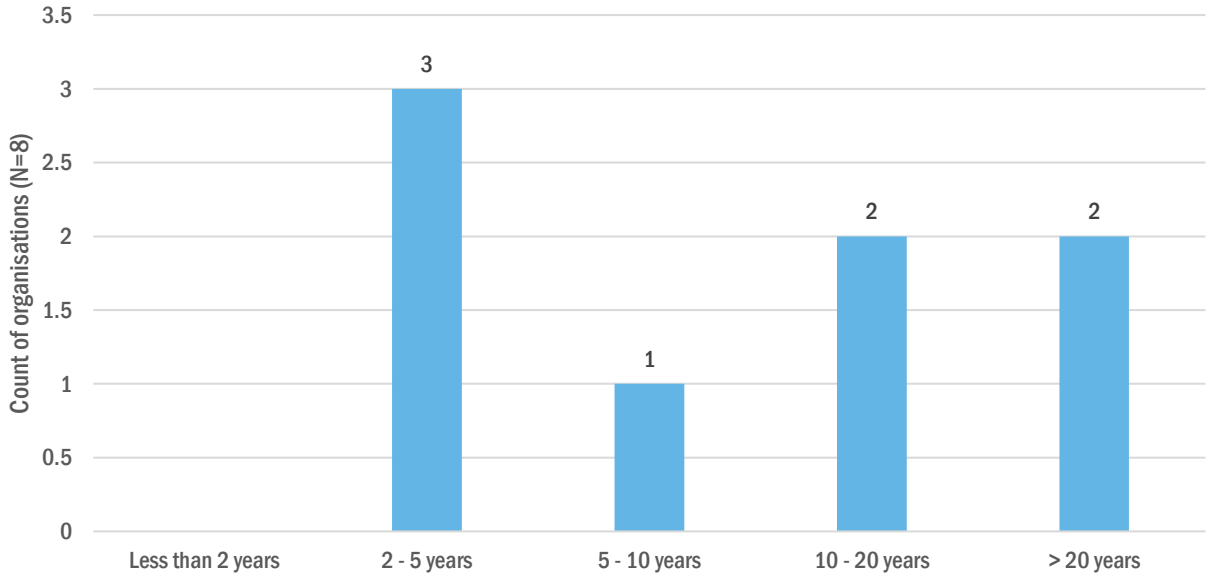


Chart C.6 Turnover range

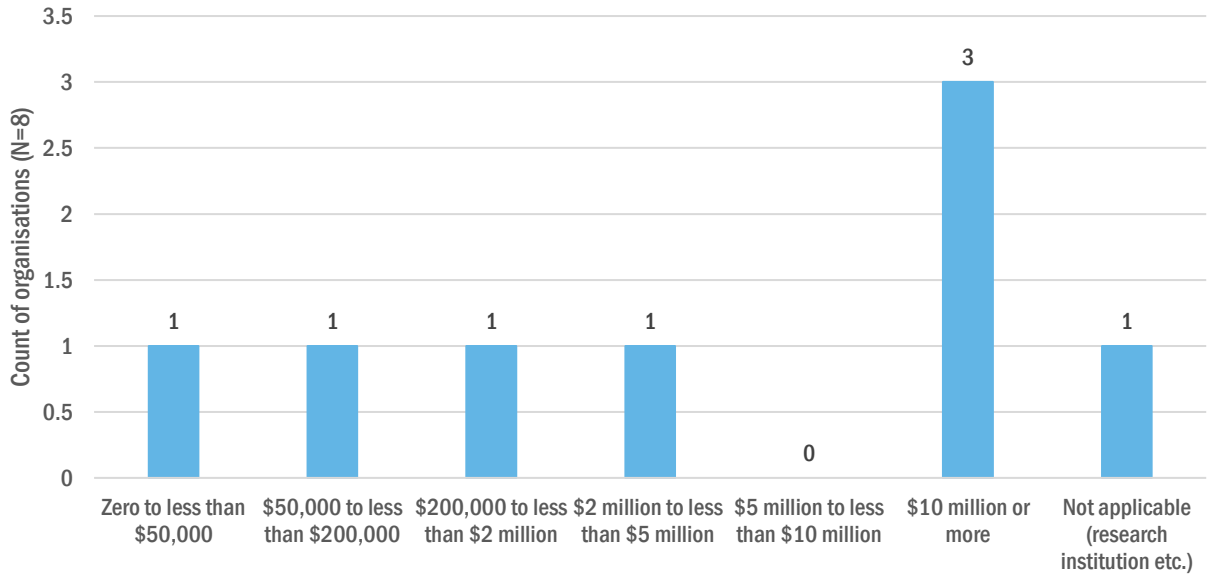


Chart C.7 FTEs

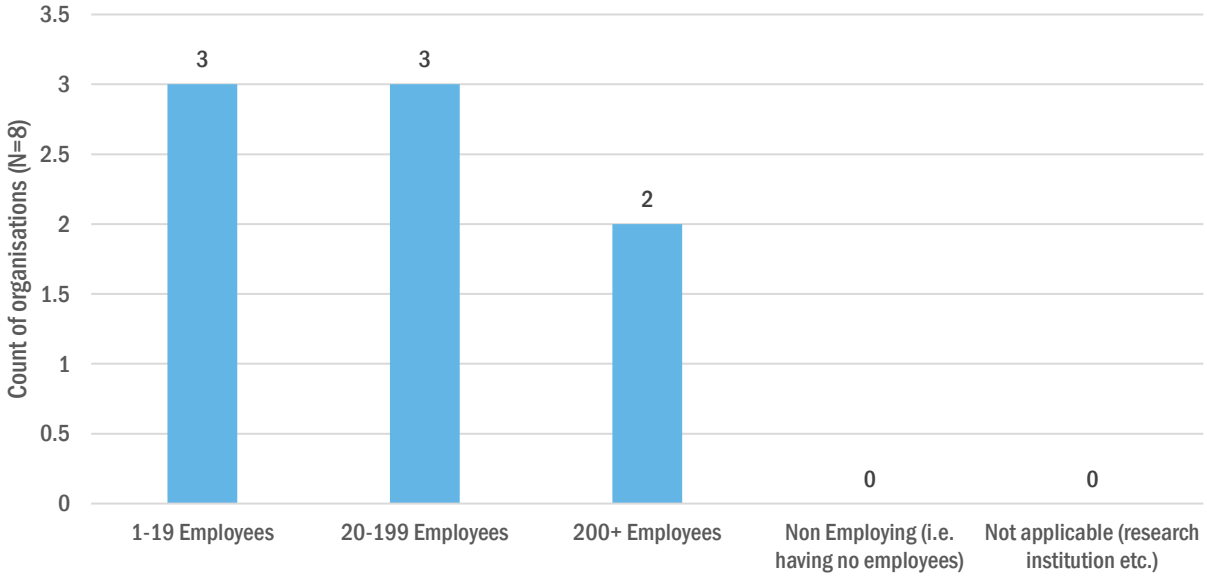
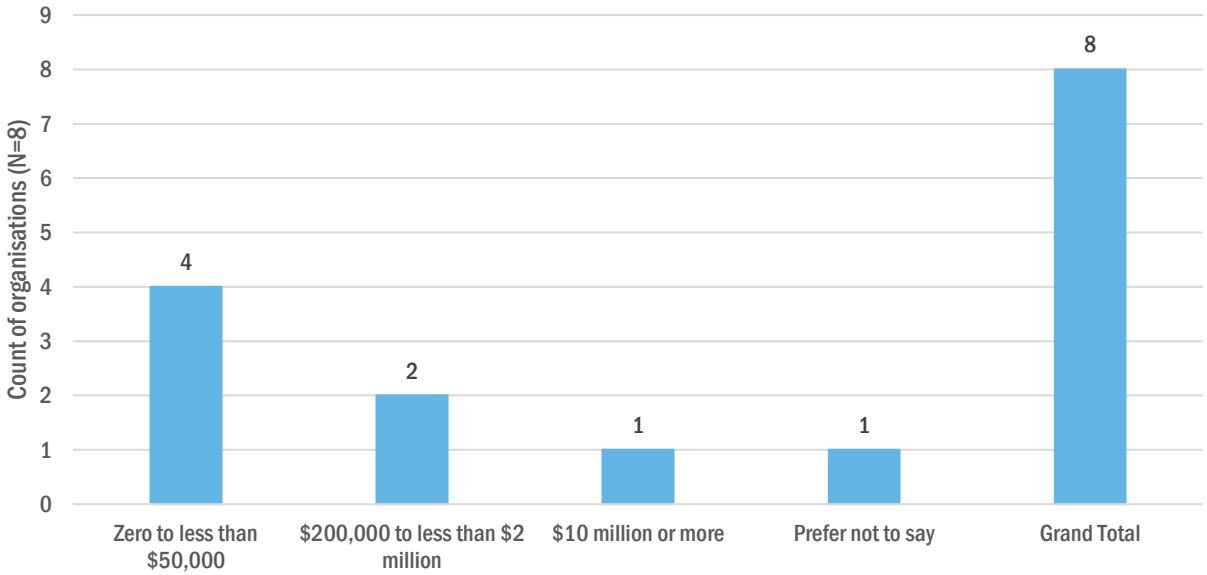


Chart C.8 Value of exports from space activities



Space Applications

Chart C.9 Duration of operations

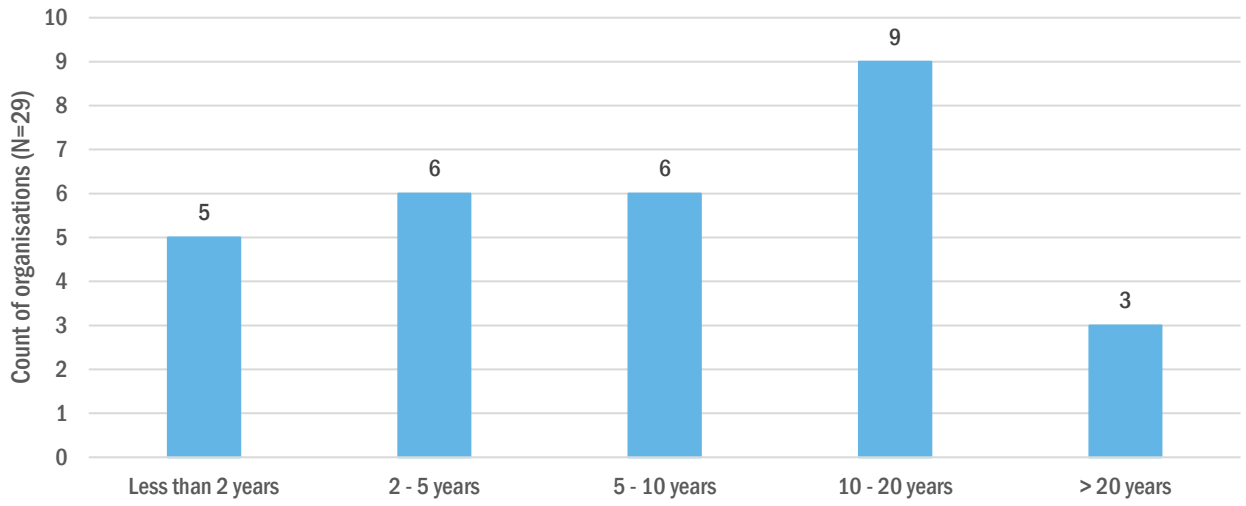


Chart C.10 Turnover range

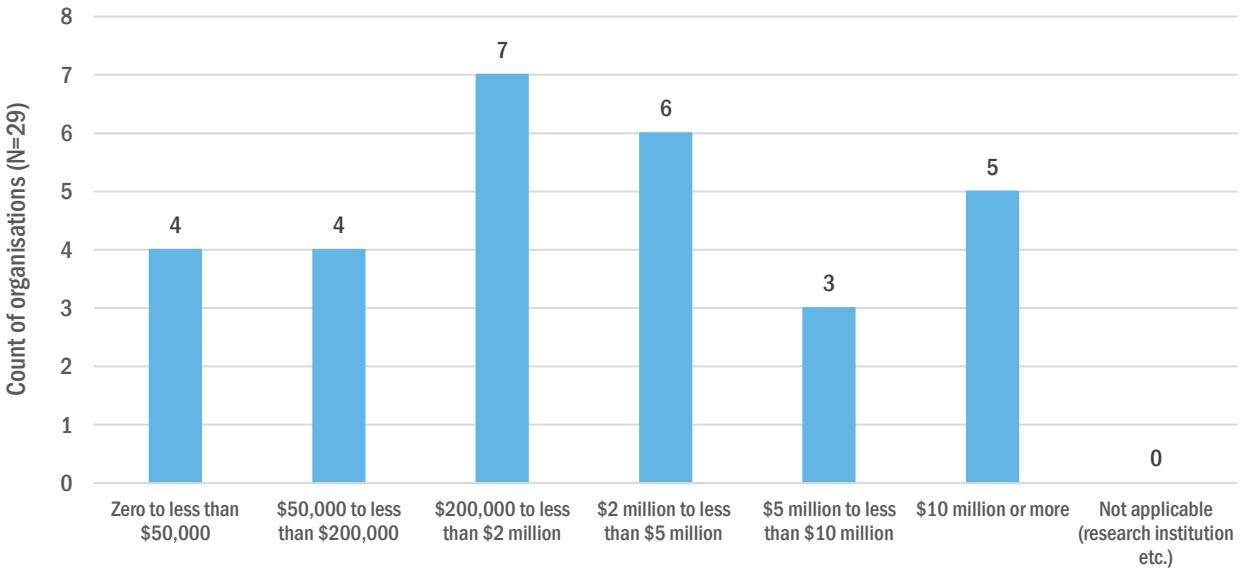


Chart C.11 FTEs

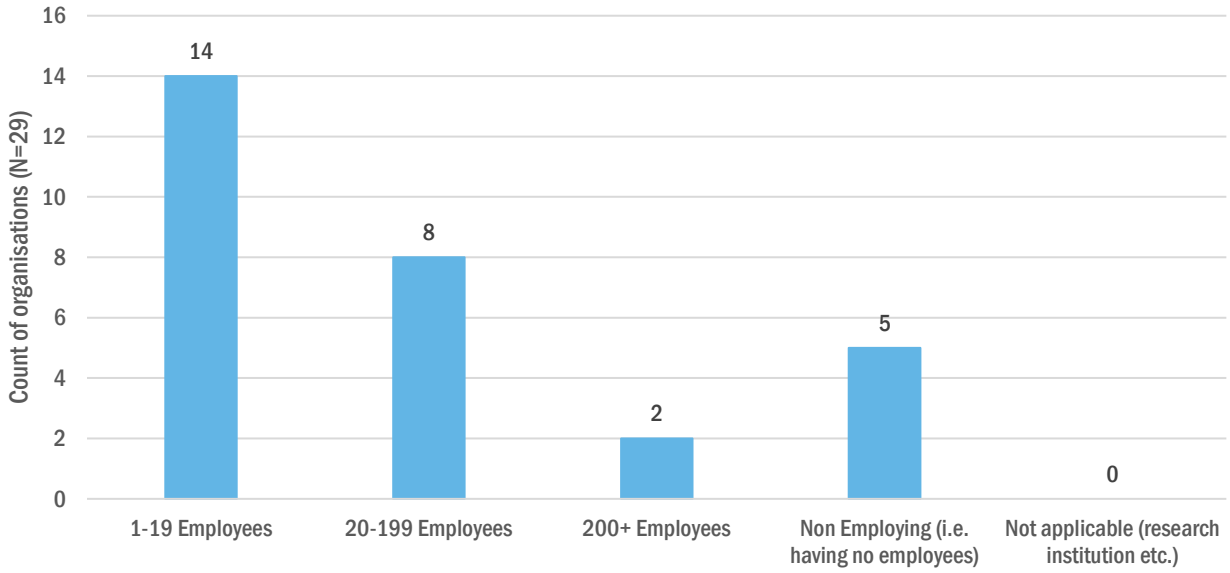
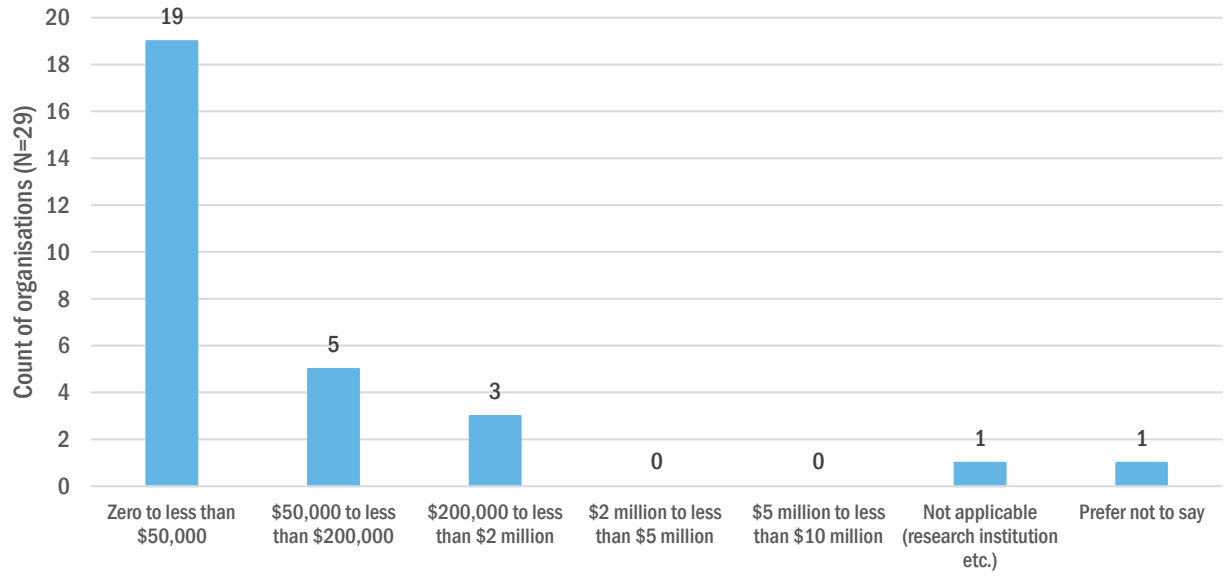


Chart C.12 Value of exports from space activities.



Ancillary Services

Chart C.13 Duration of operations

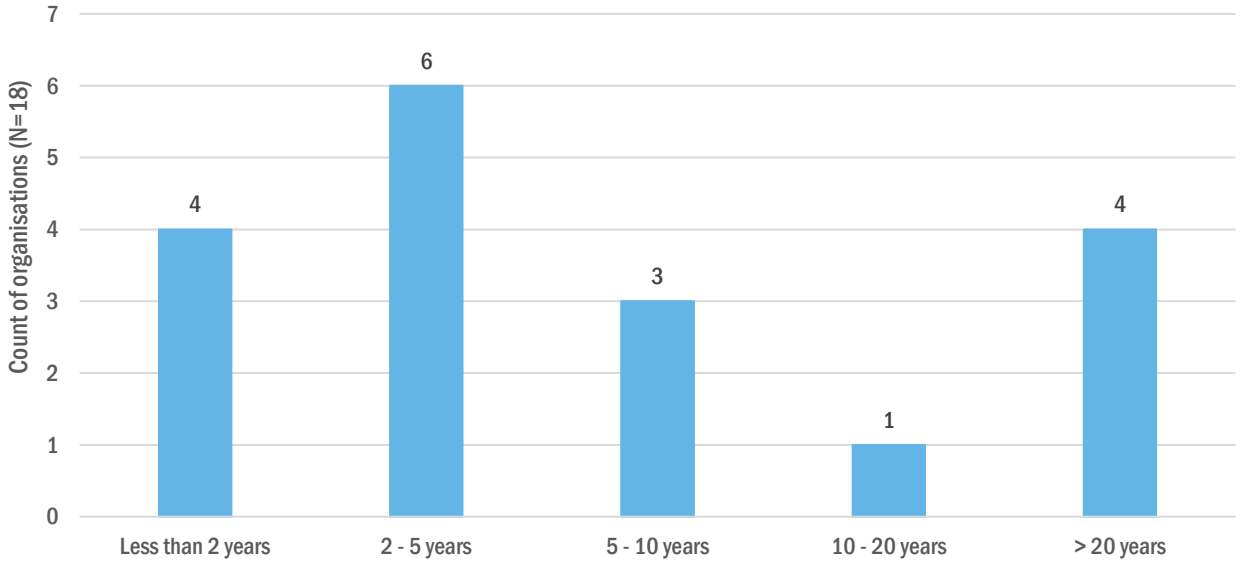


Chart C.14 Turnover range

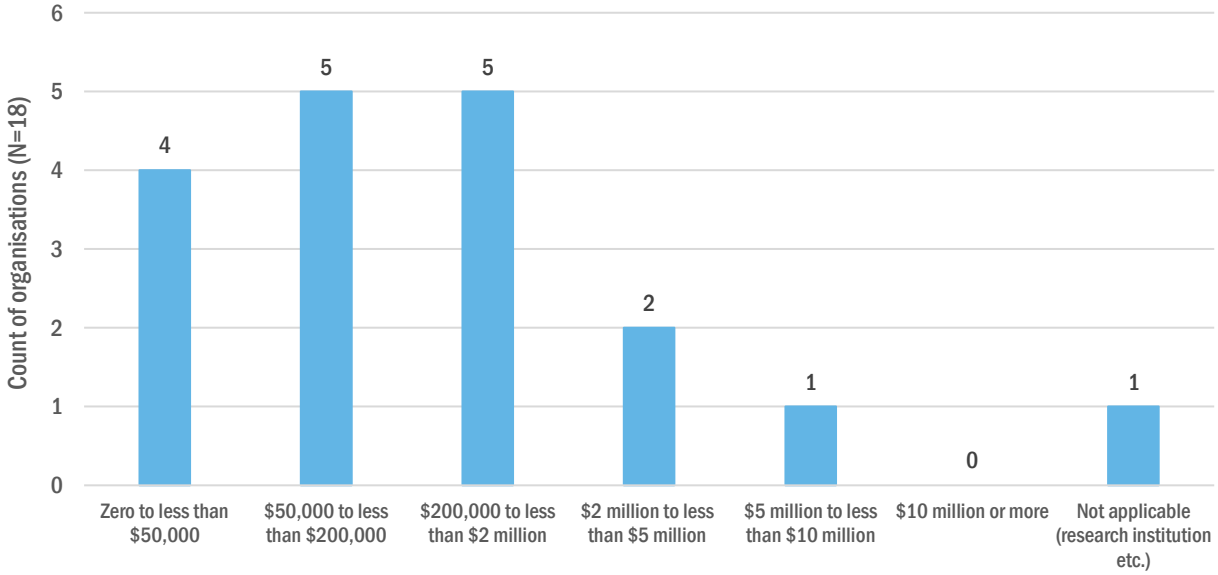


Chart C.15 FTEs

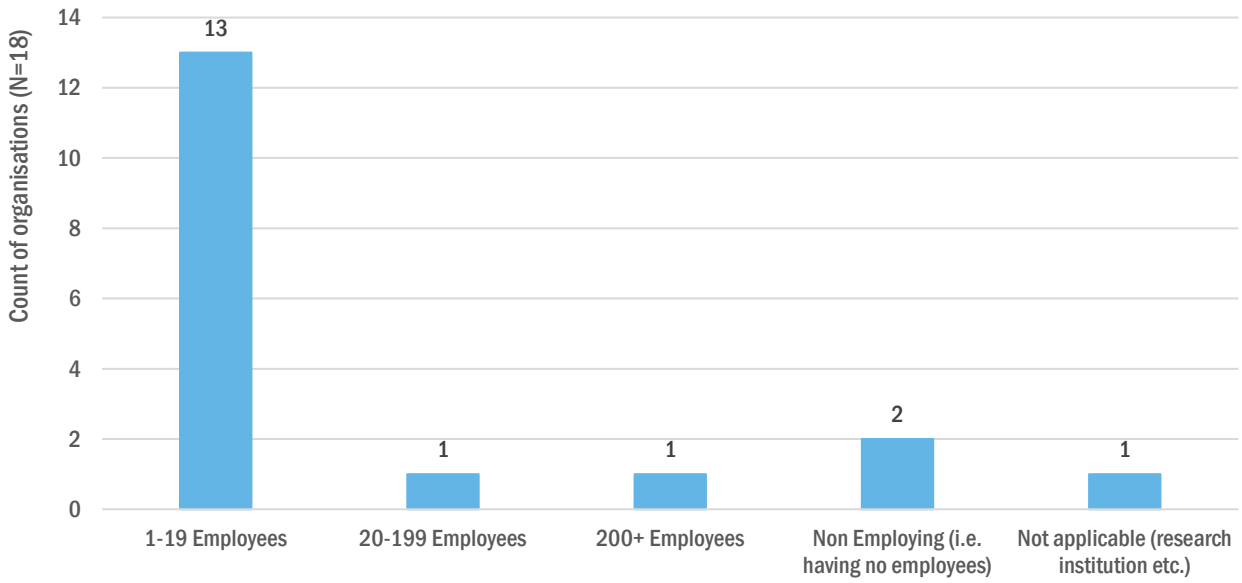
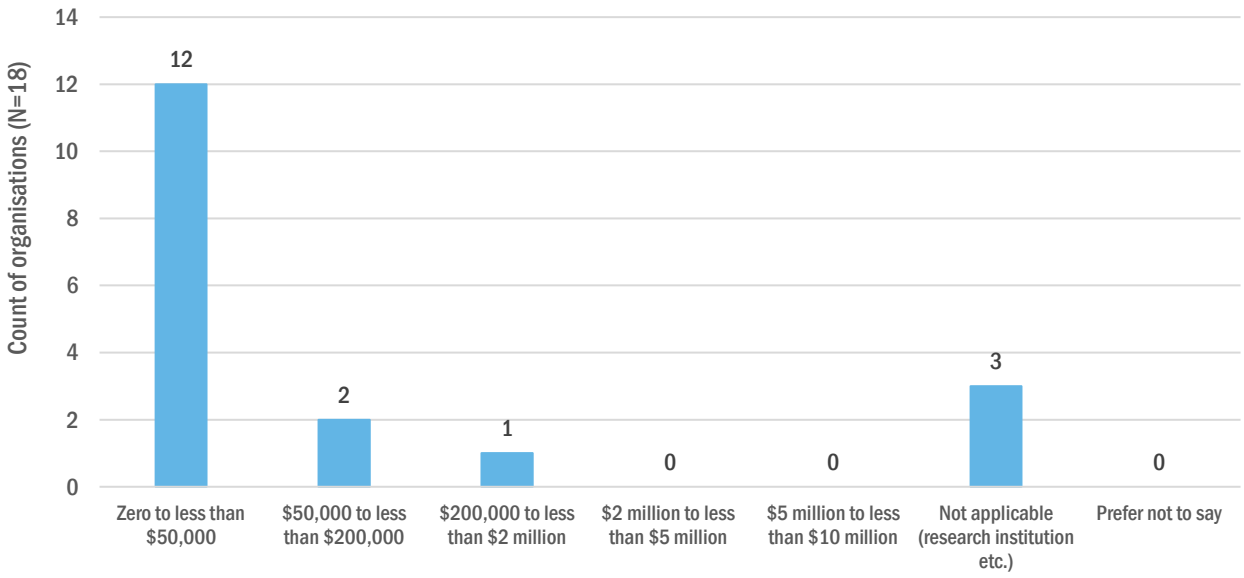


Chart C.16 Value of exports from space activities



Government

Chart C.17 Duration of operations

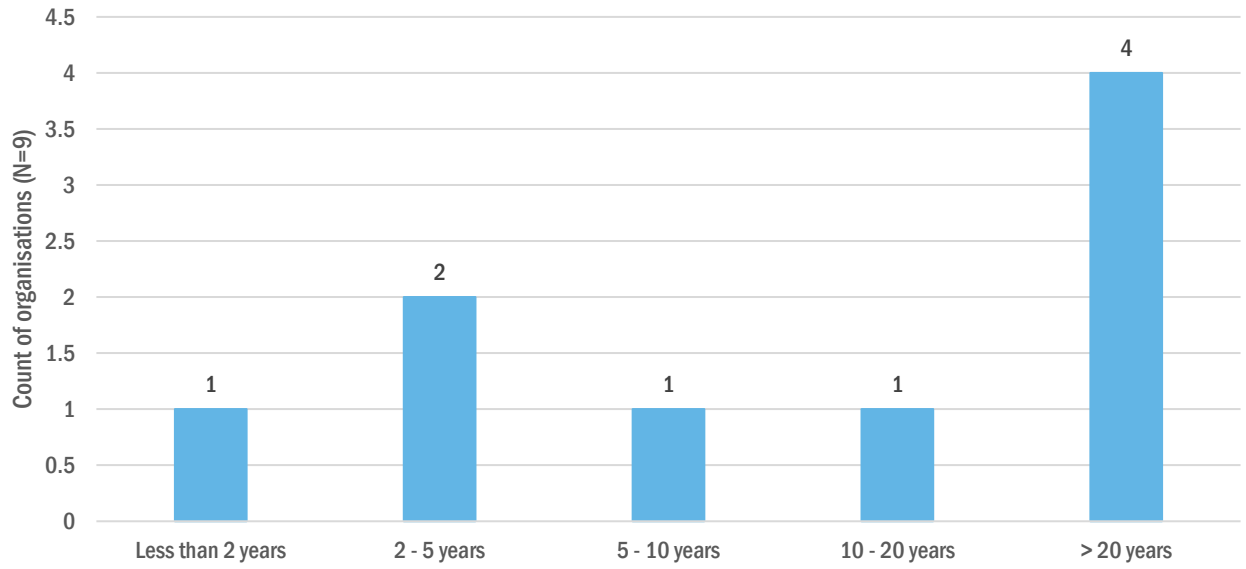


Chart C.18 Turnover range

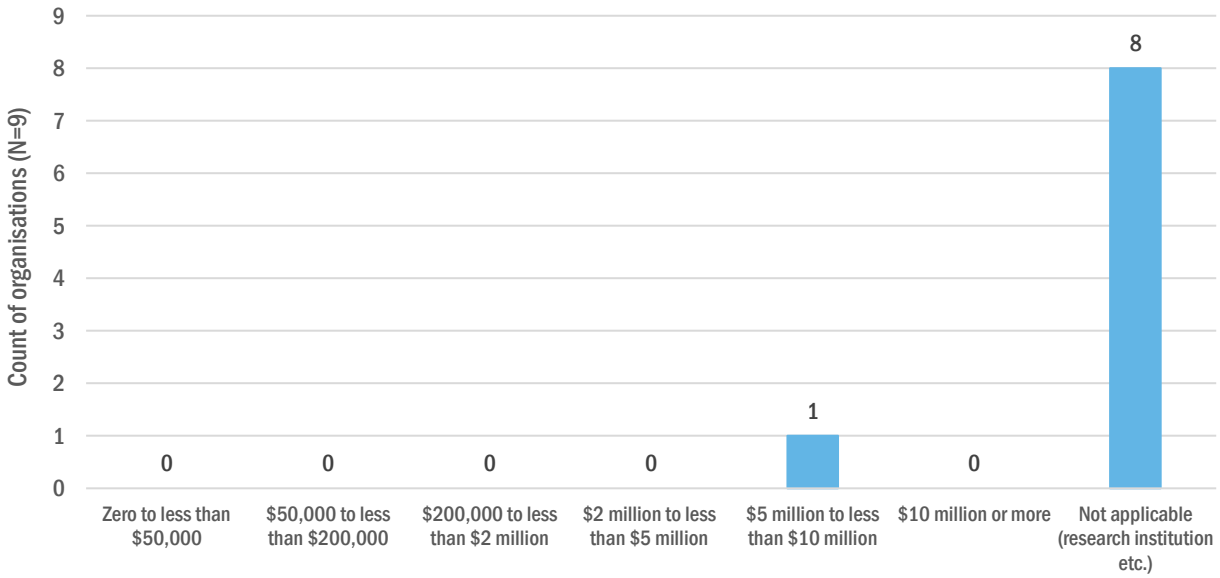


Chart C.19 FTEs

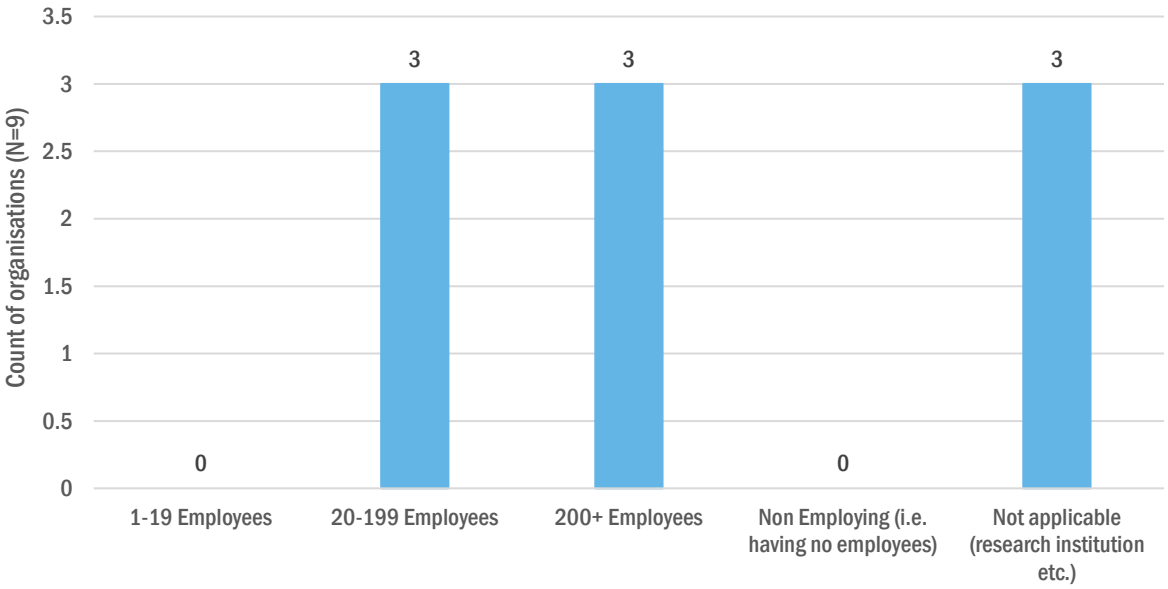
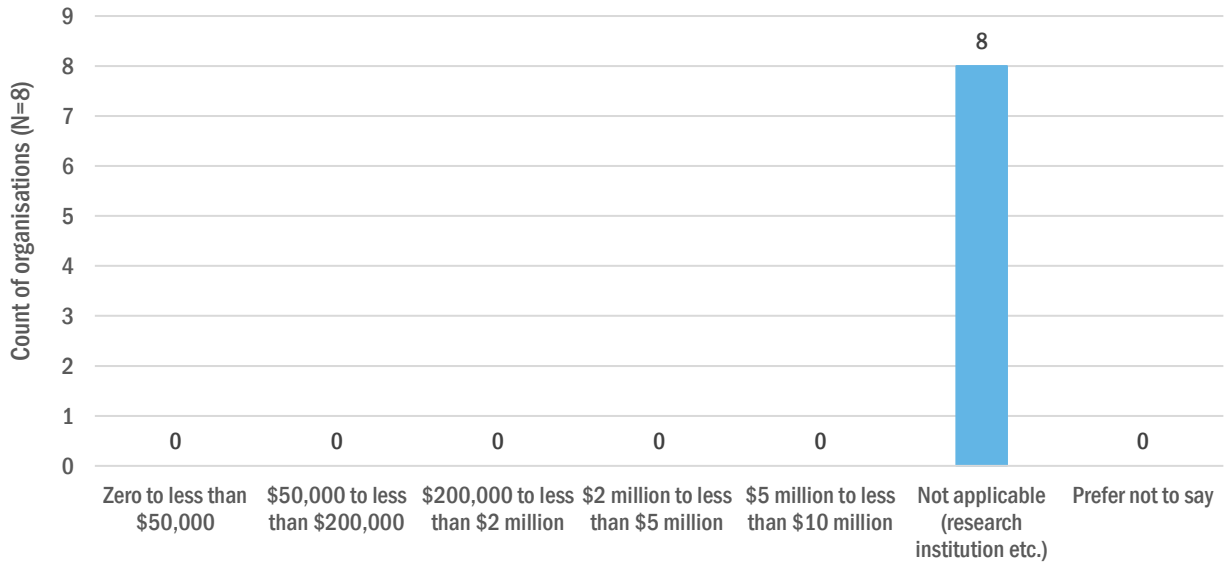


Chart C.20 Value of exports from space activities



Research & Development (R&D)

Chart C.21 Duration of operations

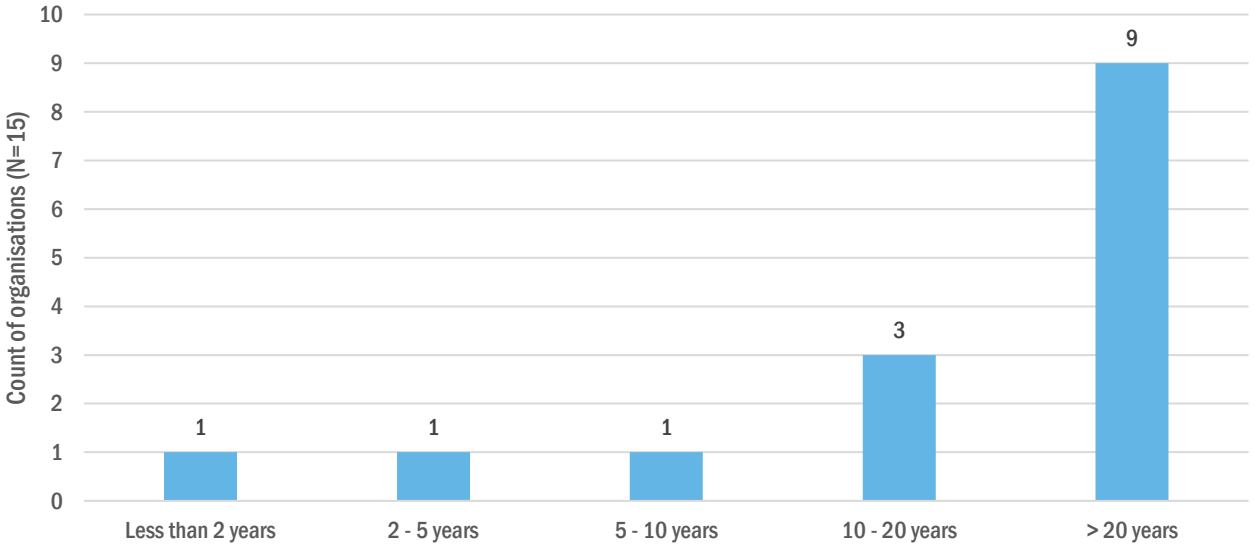


Chart C.22 Turnover range

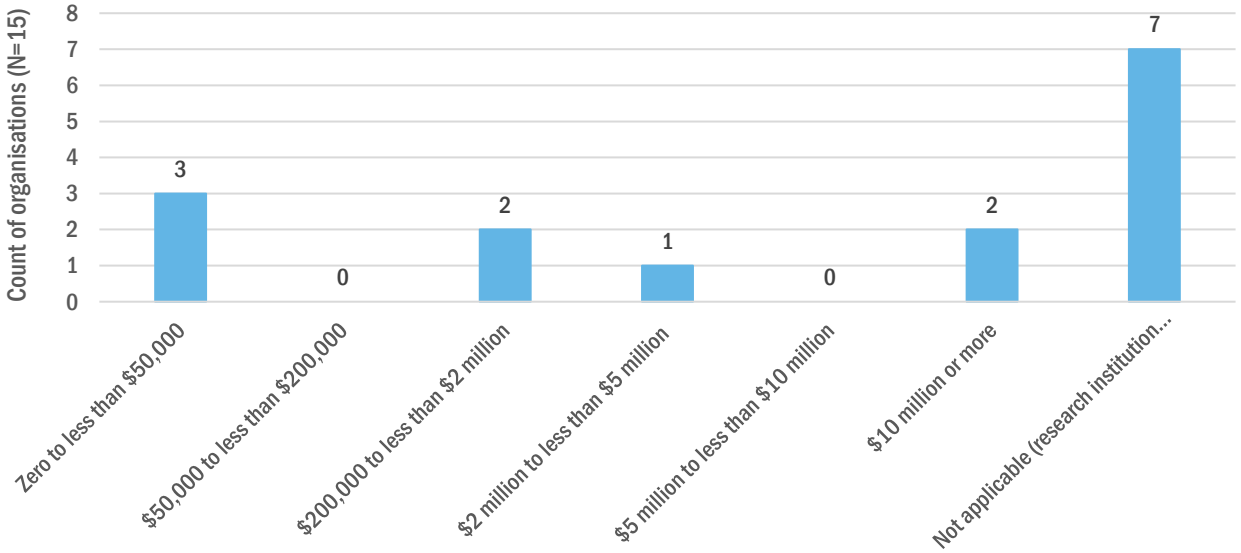


Chart C.23 FTEs

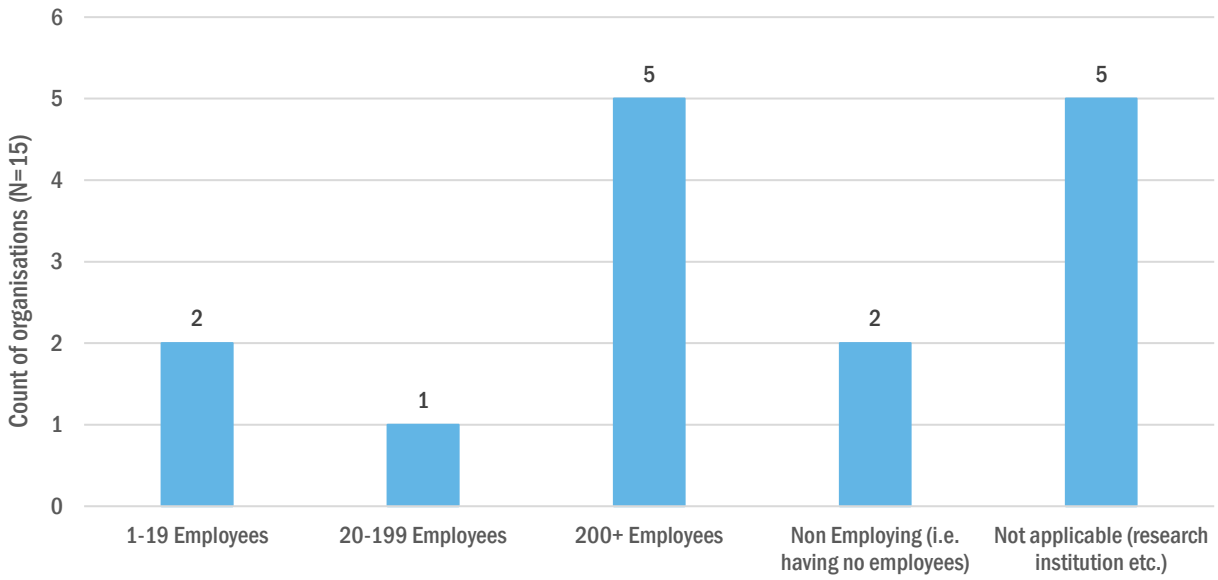
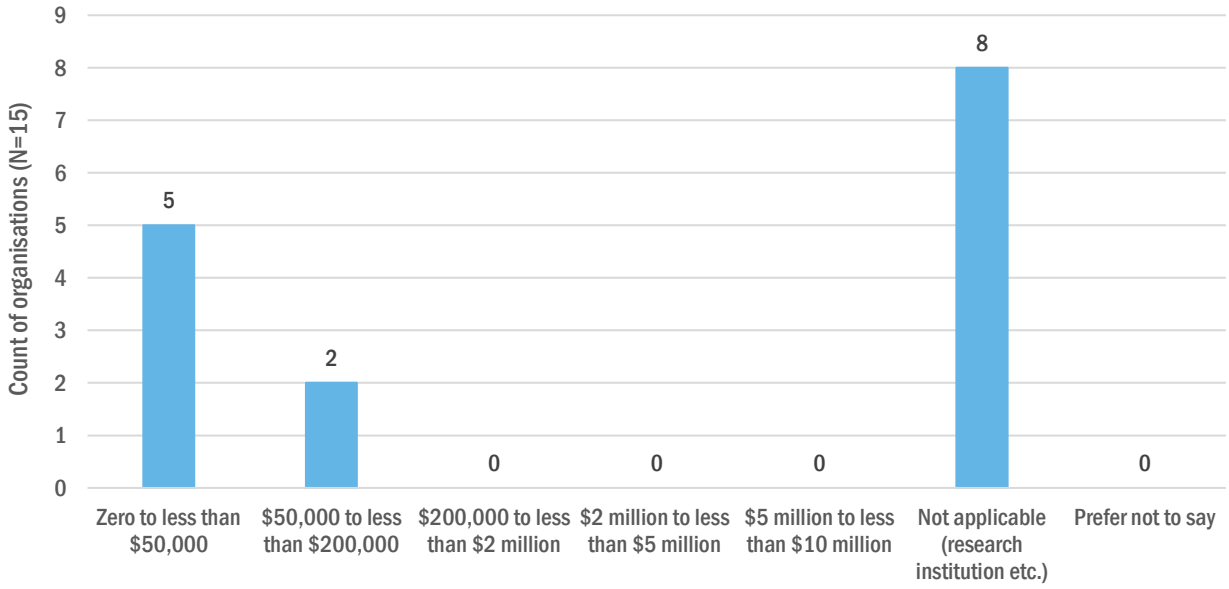


Chart C.24 Value of exports from space activities

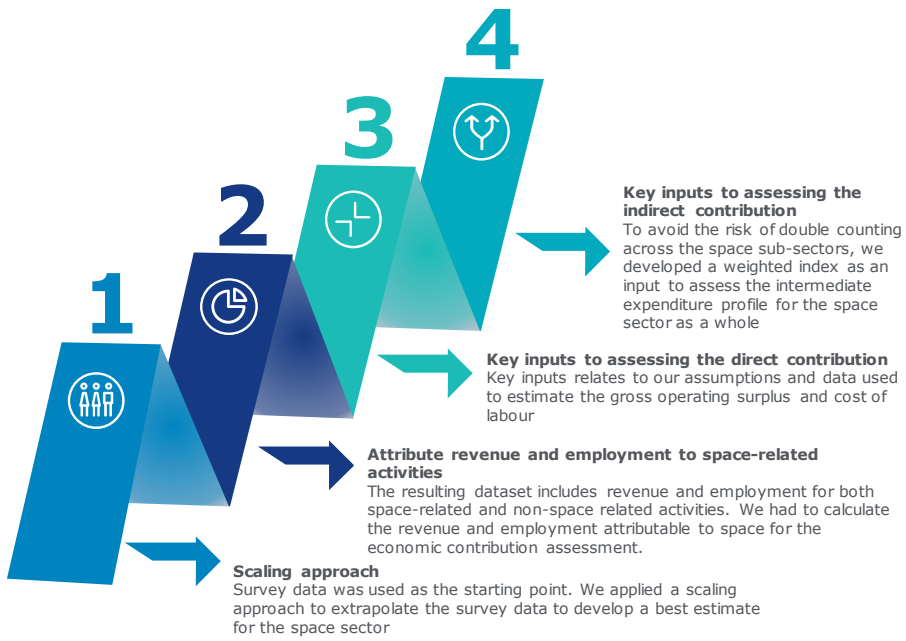


Appendix D Key modelling inputs and assumptions

Overview

The appendix describes the key modelling inputs and assumptions used in Part II of this report. These modelling inputs are depicted in the stylised figure below:

Figure E.1: Key modelling inputs



Source: Deloitte Access Economics

Extrapolate the survey sample to the total population of the space sector

Two key inputs to the model are revenue and employment, but, as evident from the survey questions presented in Appendix F, survey responses on these metrics were provided within a range. Hence, the mid-point of the range for both revenue and employment was used an input to the analysis. For example:

- If a response indicated that a company employed 1 to 19 workers, a value of 10 was used in the model.
- If a response indicated that a company generated between $2 million and $5 million, a value of $3.5 million was used in the model.

As explained in Chapter 5, there were a number of missing responses to the survey that was distributed. To generalise survey results to the total space sector, a scaling approach was adopted. This comprised three steps.

Commercial entities who did not complete the survey were identified and their primary sub-sector determined. Examples of companies that were added include Sky TV and EROAD.

Financial data for organisations generating $10 million per annum or more was then sourced. These organisations, with additional commercial participants who did not complete the survey, had their revenue and employment information completed, and in some cases substituted, with up-to-date financial information. Revenue and employment information for the provision of broadband services via satellite technology, as estimated by the Commerce Commission in its annual reporting on the telecommunications sector in New Zealand, was finally added.

By applying a scaling factor, Deloitte Access Economics then extrapolated this sample to provide a best estimate for the total population of the space sector. The scaling factor for each sub-sector was informed by the entire distribution list of 220 organisations, in addition to the 104 responses to the online survey. Organisations that were identified as non-commercial, government funded or operated organisations, or tertiary institutes, were removed from the distribution list. The resulting 51 organisations who did not complete the survey, informed the scaling factor for each sub-sector. For instance, of 17 R&D sub-sector organisations, two failed to complete the survey. This implies a scaling factor of 12%, which was then used to upscale the sample.

Table E.1: Scaling by sub-sector

Sub-sector	Respondents	Non-respondents	Scaling factor
Space Manufacturing	25	10	29%
Space Operations	8	0	0%
Space Applications	29	18	38%
Ancillary Services	18	21	54%
R&D	15	2	12%
Total	**95**	**51**	

Source: Deloitte Access Economics
** Nine government organisations were excluded from the economic contribution assessment; this is because commercial revenue was used as a basis to assess the economic contribution.*

Calculate the revenue and employment attributable to space-related activities

In estimating the total revenue and economic contribution of the space sector, it is important to only account for revenues and employment attributable to space activities. For this reason, non-core space revenues and employment were excluded from the analysis.

To determine proportions, survey responses to the question "*What percentage of your annual turnover range would you classify as primarily related to space economy activities in FY18?*" were utilised. These were used as inputs to attribute total revenue and employment to space related activities. For example, total revenue for Space Manufacturing would be multiplied by 40% to determine the revenue attributable to Space Manufacturing.

Table E.2: Average proportion of space related activities by sub-sector

Sub-sector	Average proportion (%)
Space Manufacturing	40%
Space Operations	74%
Space Applications	42%
Ancillary Services	47%
R&D	32%
Overall average	**41%**

Source: Deloitte Access Economics

The proportions in the table above indicate employment attributable to space-related activities. These were determined by asking "*with respect to your organisation's activities in New Zealand, how many employees performed activities related to space in FY18*?".

Key inputs to assessing the direct contribution

Direct economic contribution captures the economic activity of the space sector itself, and is measured as the value added by the activities of businesses (i.e. the sum of returns to labour and capital) within the space sector.

Direct contribution is estimated using the income approach to GDP, which sums returns to capital and returns to labour. Returns to capital are calculated through Gross Operating Surplus (GOS), while returns to labour are determined through wages and salaries.

Return on capital

Deloitte Access Economics' estimate of GOS is informed by the estimated total revenue for each sub-sector and the Earnings Before Interest, Taxes, Depreciation, and Amortisation (EBITDA) for each sub-sector. EBITDA also includes net tax on production. EBITDA for each sub-sector was captured by confidential survey responses for key companies in each sub-sector, and international benchmarks, where publically available.

Due to the confidential nature of EBITDA benchmarks, Deloitte Access Economics cannot disclose the inputs used for this modelling exercise. However, the table below provides the resulting GOS for each space sub-sector.

Table E.3: Gross operating surplus for each space sub-sector

Sub-sector	NZD, millions in 2018-19
Space Manufacturing	53
Space Operations	32
Space Applications	244
Ancillary Services	48
R&D	25
Total	**402**

Source: Deloitte Access Economics

Return on labour

Modelling estimates are based on both space-related FTEs for each space sub-sector and the current cost of labour for each sub-sector. The table below provides the modelling inputs and resulting return on labour for each space sub-sector.

Table E.4: Gross operating surplus for each space sub-sector

Sub-sector	FTE jobs (Headcount)	Average cost of labour (NZD in 2018-19)	Return to labour (NZD, millions in 2018-19)
Space Manufacturing	1,417	75,456	107
Space Operations	1,223	137,000	167
Space Applications	1,579	97,338	154
Ancillary Services	415	72,732	30
R&D	414	87,385	36
Total	**5,048**		**494**

Source: Deloitte Access Economics

Key inputs to assessing the indirect contribution

The space sector supports wider business activity and service sectors in New Zealand, as reflected in its indirect economic contribution. Indirect economic contribution captures the flow-on effects of the space sector's expenditure on intermediate inputs, and is estimated using Deloitte Access Economics' in-house input-output (IO) model.

To estimate indirect contribution using the in-house IO model, two inputs are required:

- An estimate of the space sector's total expenditure, excluding labour costs.
    - The space sector's non-wage expenditures were derived from the total revenue estimate, EBITDA and total cost of labour.
- An intermediate expenditure profile.
    - Deloitte Access Economics developed a weighted index across space sub-sectors to estimate the intermediate expenditure profile for the space sector.

Weighted index for the space sector

The primary reason for developing this index was to avoid double counting across the space sub-sectors.

While this analysis attempted to align sub-sectors as closely as possible with their definitions, there were some differences relating to the calculation of the indirect contribution for the space sector. This is due the nature of IO tables and modelling used for in this report. For this reason, Deloitte Access Economics matched each space sub-sector with its most closely related ANZSIC code to provide the best proxy for that space sub-sector.

Table E.5: Best proxy ANZSIC code for each space sub-sector

Sub-sector	ANZSIC
Space Manufacturing	Aircraft manufacturing and repair services
Space Operations	Air and space transport
Space Applications	Broadcasting and internet publishing; Telecommunications services
Ancillary services	Advertising, market research, and management services; Auxiliary finance and insurance services
Research & Development	Education and Training

Source: Deloitte Access Economics

Intermediate expenditure profiles for each of the ANZSIC codes were used, as determined in Deloitte Access Economics' in-house IO model. Intermediate expenditure profiles capture the expenditure footprint for each sector across all the sectors in the economy. Each profile was then adjusted with a revenue weight for each space sub-sector. For example, Space Applications (57%), Space Manufacturing (13%), Ancillary Services (13%), Space Operations (9%) and Research and Development (7%). The resulting output was used to assess the indirect contribution for the entire space sector.

Appendix E Input-output modelling

Input-output tables account for the intermediate flows between industries. These tables measure the direct economic activity of every industry in the economy at the national level. Additionally, these tables allow intermediate inputs to be examined further by their source. Detailed intermediate flows may be used to derive the total change in economic activity associated with a given direct change in activity for a given industry.

A widely used measure of the spill-over of activity from one industry to another is captured by the ratio of the total to direct change in economic activity. The resulting estimate is typically referred to as the 'multiplier'. A multiplier greater than one implies some indirect activity, with higher multipliers indicating relatively larger indirect and total activity flowing from a given level of direct activity.

The table below provides a definition for each of the key results outcomes in an economic contribution study.

Table F.1: Definitions of economic contribution estimates

Estimate	Definition
Gross operating surplus (GOS)	GOS represents the value of income generated by the entity's direct capital inputs, generally measured as the earnings before interest, tax, depreciation, and amortisation (EBITDA).
Labour income	Labour income is a subcomponent of value added. It represents the value of production generated by the entity's direct labour inputs, as measured by the income to labour.
Value added	Value added measures the value of production (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital) as measured in the income to those factors of production.
Employment (FTE)	Employment is a fundamentally different measure of activity to those above. It measures the number of workers (measured in full-time equivalent terms) that are employed by the entity, rather than the value of the workers' product.
Direct economic contribution	The direct economic contribution is a representation of the flow from labour and capital committed in the economic activity.
Indirect economic contribution	The indirect contribution is a measure of the demand for goods and services produced in other industries as a result of demand generated by economic activity.
Total economic contribution	The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Source: Deloitte Access Economics

Value added approach

There are several commonly used measures of economic activity, each of which represent a different aspect of an industry's economic contribution.

Value added measures the value of production (i.e. goods and services) generated by the entity's factors of production (i.e. labour and capital), as measured by the income to those factors of production. The sum of value added across all entities within the economy equals gross domestic product. Given the relationship with GDP, the value added measure may be thought of as the increased contribution to welfare.

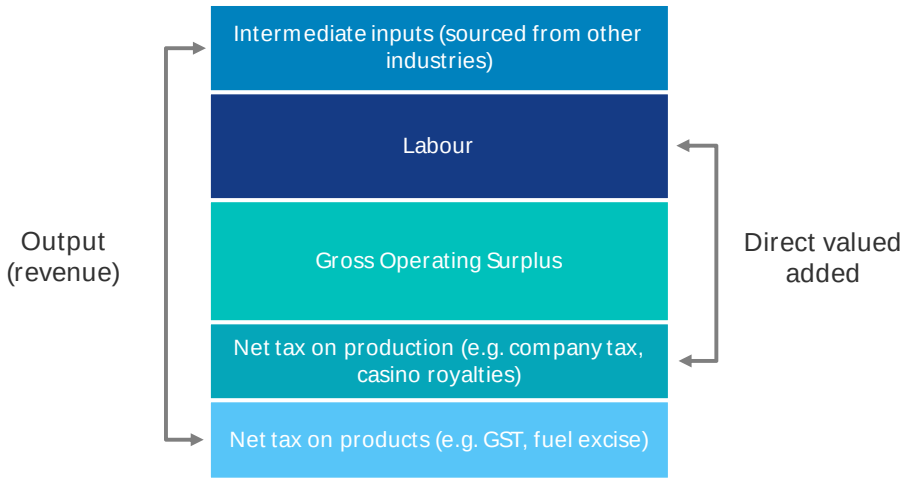
Value added is the sum of:

- Gross operating surplus (GOS)
- Tax on production less subsidies provided for production[VII]
- Labour income.

The accounting framework (Figure D.1) is used to evaluate economic activity, along with the components that comprise output. Output is the sum of value added and the value of intermediate inputs used by the firm. Net taxes on products are not included in value added but are included in GDP.

The value of intermediate inputs may also be calculated directly by summing up expenses related to non-primary factor inputs.

Figure F.1: Economic activity accounting framework



Source: Deloitte Access Economics.

Contribution studies generally outline employment generated by an entity or industry. Employment is a fundamentally different measure of activity to those above. It measures the number of workers that are employed by the entity or industry, rather than the value of the workers' production.

Direct and indirect contributions

Direct economic contribution is a representation of the flow of resources from labour and capital within the sector of the economy in question.

[VII] Given the manner in which returns to capital before tax are calculated, company tax is not included or this would double-count that tax. In addition, it excludes goods and services tax, which is a tax on consumption (i.e. levied on households).

Indirect contribution measures the demand for goods and services produced in other sectors as a result of demand generated by the sector in question. Indirect economic contribution is estimated via an input-output (IO) framework using the Statistics New Zealand 2013 IO tables. The industry classification used for IO tables is based on the Australian and New Zealand Standard Industrial Classification (ANZSIC), with 106 sectors in the modelling framework.

The total economic contribution to the economy is the sum of the direct and indirect economic contributions.

Limitations of economic contribution studies

While describing the geographic origin of production inputs may be a guide to a firm's linkages with the local economy, it should be recognised that these are the type of normal industry linkages that characterise all economic activities.

Unless there is unused capacity in the economy (such as unemployed labour), there may not be a robust relationship between a firm's economic contribution as measured by value added (or other static aggregates) and the welfare or living standard of the community. Indeed, the use of labour and capital by an industry comes at an opportunity cost, as it may reduce the amount of resources available to allocate to other sectors within the economy.

In a fundamental sense, economic contribution studies are simply historical accounting exercises. No 'what-if', or counterfactual inferences – such as 'what would happen to living standards if the firm disappeared?' – should be drawn from them.

The analysis used in this report relies on a national IO table modelling framework, and there are some limitations to consider. The IO framework and the derivation of the multipliers also assume that relevant economic activity takes place within an unconstrained environment. That is, an increase in economic activity in one area of the economy does not increase prices and subsequently crowd out economic activity in another area of the economy. As a result, the modelled total and indirect contribution may be regarded as an upper-bound estimate of the contribution made by the supply of intermediate inputs.

Appendix F Survey questions

Below is the list of questions from the data capture survey. The questions below were not compulsory, therefore the survey analysis varies in total responses for each questions.

Due to confidentiality agreements, participant's answers have not been included.

Table G.1: Survey questions

1	**Organisation name**	[Free text]
2	**Contact**	[Free text]
3	**Website**	[Free text]
4	**NZBN (N/A if an individual)**	[Free text]
5	**How have you received this survey?**	
	Customer	
	Supplier	
	Organisation Name	[Free text]
6	**Location of headquarters:**	
	Street	[Free text]
	Suburb	[Free text]
	City	[Free text]
	Postcode	[Free text]
	Country	[Free text]
7	**Location of New Zealand operations:**	
	Same as above	
	Different from above	
	If different from above please fill in below:	
	Street	[Free text]
	Suburb	[Free text]

	City	[Free text]
	Postcode	[Free text]
	Country	[Free text]

8	**How long has your organisation been in operation?**
	Less than 2 years
	2 – 5 years
	5 – 10 years
	10 – 20 years
	> 20 years

9	**Please select which statement best represents your organisation's current level of engagement and/or activity in the space economy*:**
	My organisation (or as an individual) occasionally operates in the space economy
	My organisation (or as an individual) is not currently active in the space economy
	My organisation (or as an individual) has recently entered the space economy
	The space economy is a secondary area of operation for my business
	The space economy is a core area of operation for my business

*Space Economy: Using the OECD definition, the space economy is the full range of activities and use of resources that create and provide value and benefits to human beings in the course of exploring, understanding, managing and utilising space. It includes all public and private actors involved in developing, providing and using space-enabled products and services, ranging from research and development, the manufacture and use of space infrastructure (ground stations, launch vehicles and satellites) to space-enabled applications (navigation equipment, satellite phones, meteorological services, etc.) and the scientific knowledge generated by such activities.

10	**Do you consider the space economy your primary industry of operation?**
	Yes
	No
	I don't know

11	**If the space economy is not your primary industry of operation, what is?**
	Agriculture, Forestry and Fishing
	Construction
	Defence

	Education and Training	
	Finance, Insurance and Business Services	
	Information Media and Telecommunications	
	Manufacturing	
	Other Services	
	Professional, Scientific and Technical Services	
	Trade	
	Transport	
	Utilities	
	Don't know	
	Other, please specify	[Free text]

*Education and Training: this sub-sector was removed from this analysis and affiliated organisations were re-allocated to appropriate sub-sector(s).

*Other: this sub-sector was removed from this analysis and affiliated organisations were re-allocated to appropriate sub-sector(s).

12	**Please nominate which of the following sub-sector(s) of the space economy you operate in:**
	Space Manufacturing - Launch vehicles and subsystems
	Space Manufacturing - Satellites/payloads/spacecraft and subsystems
	Space Manufacturing - Scientific instruments
	Space Manufacturing - Ground segment systems and equipment (control centres and telemetry)
	Space Manufacturing - Suppliers of materials and components
	Space Manufacturing - Scientific and engineering support
	Space Manufacturing - Fundamental and applied research
	Space Manufacturing - Specialisation on nano and micro satellites (<50kg)
	Space Operations - Launch services
	Space Operations - Launch brokerage services
	Space Operations - Proprietary satellite operation (including sale/lease of capacity)
	Space Operations - Third-party ground segment operations
	Space Operations - Ground station networks
	Space Applications - Direct-To-Home (DTH) broadcasting
	Space Applications - Fixed and mobile satellite communications services (including VSAT)
	Space Applications - Location-based signal and connectivity service provider

	Space Applications - Supply of user devices and equipment
	Space Applications - Processors of satellite data
	Space Applications - Earth Observation Services & Applications
	Space Applications - Satellite Communications Services Providers
	Space Applications - Satellite Navigation Service & Applications
	Space Applications - User of Space Enabled Services
	Please specify your use of Space Enabled Services [Free text]
	Ancillary services - Launch and satellite insurance (including brokerage) services
	Ancillary services - Financial services
	Ancillary services - Legal services
	Ancillary services - Construction
	Ancillary services - Software and IT services
	Ancillary services - Market research and consultancy services
	Ancillary services - Business incubation and development
	Research & development - Commercial
	Research & development - Education
	Government - Policy-making
	Government - Regulation
	Government - Oversight

*Education and Training: this sub-sector was removed from this analysis and affiliated organisations were re-allocated to appropriate sub-sector(s).

*Other: this sub-sector was removed from this analysis and affiliated organisations were re-allocated to appropriate sub-sector(s).

13	**Please indicate which International Space Agencies you have worked with**	[Free text]

14	**Please briefly indicate what your organisation specialises in**	[Free text]

15	**Please describe your relationship/interaction with the rest of New Zealand's space economy**	[Free text]

16	**Does your organisation provide goods or service to any of the following industries (as well as to the space industry)?**
	Agriculture, Forestry and Fishing
	Construction

	Defence	
	Finance, Insurance and Business Services	
	Information Media and Telecommunications	
	Manufacturing	
	Other Services	
	Professional, Scientific and Technical Services	
	Trade	
	Transport	
	Utilities	
	My organisation is exclusively involved in space	
	Don't know	
	Other, please specify	[Free text]

17	**CONFIDENTIAL: What was your turnover range in FY18?**
	Zero to less than $50,000
	$50,000 to less than $200,000
	$200,000 to less than $2 million
	$2 million to less than $5 million
	$5 million to less than $10 million
	$10 million or more
	Not applicable (research institution etc.)

18	**CONFIDENTIAL: What percentage of your annual turnover range would you classify as primarily related to space economy activities in FY18?**
	None
	<20%
	21-40%
	41-60%
	>60%

*Turnover: Revenue

19	**CONFIDENTIAL: How many employees* (FTEs) did you have in FY18?**
	Non Employing (i.e. having no employees)

	1-19 Employees
	20-199 Employees
	200+ Employees
	Not applicable (research institution etc.)

*Employees: The number of persons who receive remuneration in wages or salaries, or are paid a retainer fee by their employer.

20	**CONFIDENTIAL: With respect to your organisation's activities in New Zealand, how many employees (FTEs) performed activities related to space in FY18?**	[Free text]

21	**CONFIDENTIAL: Please nominate your salaries and wages as a proportion of total business expenditure in FY18:**
	None
	<20%
	21-40%
	41-60%
	>60%

22	**Are the majority (greater than 50%) of your New Zealand-based employees New Zealand Nationals?**
	Yes
	No
	Don’t know

23	**CONFIDENTIAL: What was the value of your export activities from space economy activities in FY18?**
	Zero to less than $50,000
	$50,000 to less than $200,000
	$200,000 to less than $2 million
	$2 million to less than $5 million
	$5 million to less than $10 million
	$10 million or more
	Not applicable (research institution etc.)

24	**CONFIDENTIAL: What percentage of your products and/or services by revenue, do you export internationally?**
	None

	<20%
	21-40
	41-60%
	>60%

25	**CONFIDENTIAL: If you export your goods/services, where are your key export locations?**	[Free text]

28	**Are you part of the supply chain of a large multinational? For example, your organisation has a global parent company based elsewhere, with headquarters or an entity based in New Zealand?**
	Yes
	No
	Not applicable (research institution etc.)

29	**Do you provide goods or services exclusively to this large multinational?**
	Yes
	No

30	**CONFIDENTIAL: Have you received any financial assistance from the New Zealand Government?**
	Yes
	No
	Not applicable (research institution etc.)

31	**CONFIDENTIAL: Please nominate which streams of funding you have received financial assistance from:**	[Free text]

32	**CONFIDENTIAL: Please select the approximate range of R&D spending for space related activities that your organisation incurred in FY18**
	Zero to less than $50,000
	$50,000 to less than $200,000
	$200,000 to less than $2 million
	$2 million to less than $5 million
	$5 million to less than $10 million
	$10 million or more
	Not applicable (research institution etc.)

Limitation of our work

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