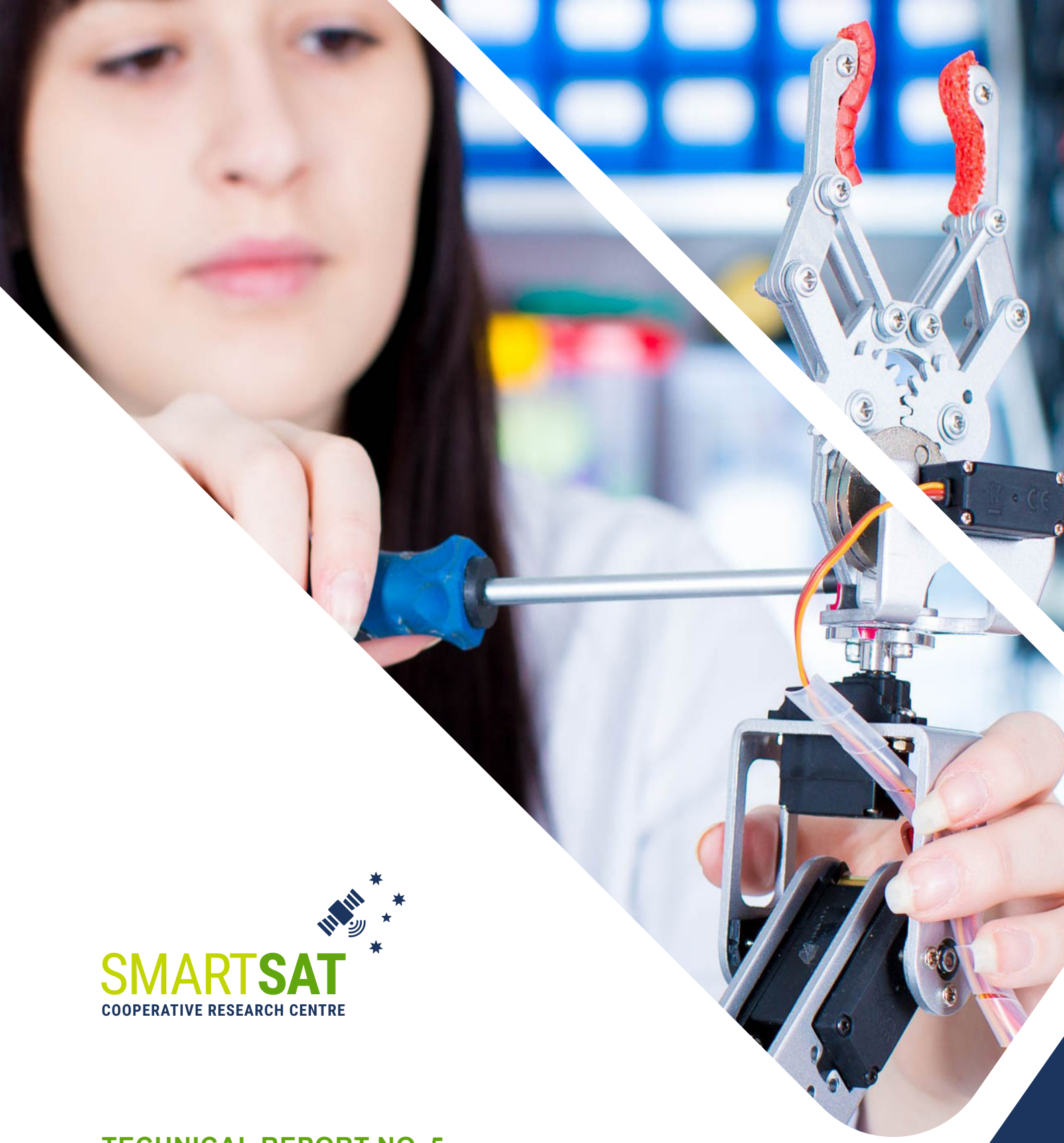

SMARTSAT
COOPERATIVE RESEARCH CENTRE

TECHNICAL REPORT NO. 5

Space Industry Skills Gap Analysis

Technical Report No. 5

Space Industry Skills Gap Analysis

March 2021

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1.0 Executive Summary

Synopsis

The study established a space-related skills taxonomy specific to Australia, comprising 319 individual skills, and found that Australia's space industry encompasses nearly every skill type with very minimal gaps. At the same time, the study found there are pervasive current shortages and future requirements across these 319 skills. The study also found there are some potential gaps in training providers for space skills, but that Australian organisations employ a range of methods beyond training, including international recruitment, to fulfill their needs.

Background and methodology

The Australian Space Agency has set some ambitious goals to triple Australian space industry revenues to A$12 billion per annum and add another 20,000 jobs to the Australian space workforce by 2030. A critical element in achieving these goals is the development of an Australian workforce with the necessary space-related skills. This will require a number of strategies, including an understanding of current skills gaps, shortages and future skills needs in the Australian space industry and ensuring we have an education and training sector that is equipped to appropriately train the Australian workforce in the relevant space-related skills.

This study was commissioned by SmartSat with support from the Australian Space Agency as an initial step to understanding the skills needs of the national space workforce. The study provides a detailed and in-depth examination and assessment of Australian space-related skills.

Development of an Australian Space Skills Taxonomy

Skills needs and gaps are typically identified by reference to a taxonomy of job skills for the sector. This study found that no job skills taxonomy exists for the space sector worldwide. Consequently, an Australian Space Skills Taxonomy (ASST) was developed as part of this study. The Western Sydney University (WSU) and Asia Pacific Aerospace Consultants (APAC) team used: space technology and product characteristics that underpin NASA and ESA projects combined with the Australian Space Agency definition of space activities; previous APAC work characterising the Australian space sector; and input from SmartSat project leads and other industry participants to develop an ASST tailored to the needs of the national space industry and the purposes of this study.

The ASST is based on a three-tier hierarchical structure of space skills covering technical and business/governance related skills. This three-tiered taxonomy architecture includes 12 Tier One Skills categories, 56 Tier Two Skills Groups and 319 specific Tier Three Skills relevant to the Australian space sector. These include technical skills; technology specific skills; business, management, and governance skills; as well as soft skills relevant to the higher education, professional development, workforce development and vocational education sectors.

This study examined current space-related skills and shortages, future skills requirements and potential training providers for these needs through the lens of the detailed and unique, three-tier ASST specifically designed for this study. Primary data used in the study was collected by a specifically designed online survey instrument, based on the ASST.

The survey elicited 90 valid responses with a good distribution across the various sectors – 62% from the private sector, 23% from the university sector, 9% from government and 6% from the not-for-profit sector, which broadly matches the current make-up of the Australian space sector. Organisations in every state and territory of Australia except Tasmania responded, comprising a mix of large organisations (26%), medium organisations (21%) and small organisations (51%), measured by revenue.

From a detailed analysis of the responses, the study identified the key current and potential future skills needs across the Australian space industry, as well as key skills needs relevant to SmartSat's three major research programs and three enabling themes. The study also identified training providers that could deliver training for the various key skills needs, and areas where there might be a shortage of training providers for specific key needs.

Definitions

Tier Three Skills - refers to the 319 individual skills listed in the ASST developed for this study

High Intensity Skills - refers to the 86 Tier Three skills that were identified in this study (through in-depth sensitivity analyses of the data) as skills that require attention due to current shortages, being indicative of high future skills demand (relative to current skills supply), or at risk of insufficient training provider capacity to deliver enough training for current and/or future skills growth needs.

Findings

This study has revealed some interesting and unexpected information about current job skills, and current and future needs for the Australian space industry:

1. Current skills exist within Australia's space industry for virtually all the 319 Tier Three space-related skills in the ASST (317 skills indicated as currently employed within organisations surveyed).

2. Current skills shortages exist in virtually all the 319 Tier Three space-related skills in the ASST (310 current skills shortages indicated within organisations surveyed).

3. Future skills requirements exist in all 319 Tier Three skills in the ASST.

4. Sensitivity analyses identified 86 Tier Three skills of high intensity based on current and future skills demand versus currently available skills and training providers able to train to the specific skills. These were identified in two groups (with many overlaps) as follows:

    - 48 skills at risk of critical current and/or future shortages in the workforce due to:
        - being skills that only exist in three or fewer organisations
        - being highlighted as potential critical shortages as more than half the organisations currently requiring the skill reported a shortage
        - skills highlighted as potential future shortages due to being a future requirement for more than double the number of organisations than those that currently employ these skills
        - skills that were identified as high intensity when current shortages and future demand were aggregated.

    - 62 skills at risk due to shortages of training providers, comprising:
        - skills with no training providers amongst survey respondents
        - skills with current shortages with more than 10 organisations in need per provider
        - skills with future demand from more than 10 organisations per training provider
        - skills identified as high intensity when current shortages and future demand were aggregated (indicating additional pressure on training providers to cater for current and future needs).

A total of 86 high intensity shortages were derived by combining skills that fit one or both of the above shortage criteria. Sensitivity analyses indicated that 41 of the 86 high intensity Tier Three skills are required by some or all of SmartSat's research programs or enabling themes.

The distribution of the 86 high intensity Tier Three Skills for each Tier One Skills Category is shown in Table 1 indicating that some categories have one or no high intensity needs while others have several.

Table 1 High intensity skills needs in each Tier One Skill category

High intensity skills needs in each Tier One skill category	Skills Needs
Category 1 - Launcher and Spacecraft Development	4
Category 2 - Satellite Payload and Sensor Development	0
Category 3 - Satellite Payload and Ground-Based Technologies Development	1
Category 4 - Space Exploration Technologies Development	15
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	17
Category 6 - Ground Systems Technologies and Services	10
Category 7 - Space Environment Monitoring Technologies	1
Category 8 - Space System Project Management	7
Category 9 - Software, Programming and Computer Skills	12
Category 10 - Space Applications	6
Category 11 - Space sector Enabling Skills	13
Category 12 - Soft Skills	0
TOTAL	**86**

The number of high intensity Tier Three skills in each Tier One Skills category that are relevant to SmartSat research programs or enabling themes is shown in Table 2. The data indicates that 41 of the 86 high intensity Tier Three skills across 10 Tier One skills categories are of particular interest to SmartSat.

Table 2 High intensity skills needs of importance to SmartSat CRC research programs

High intensity skills needs of importance to SmartSat CRC research programs in each Tier One skills category	Skills Needs
Category 1 - Launcher and Spacecraft Development Launcher and Spacecraft Development	3
Category 2 - Satellite Payload and Sensor Development	0
Category 3 - Satellite Payload and Ground-Based Technologies Development	1
Category 4 - Space Exploration Technologies Development	1
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	3
Category 6 - Ground Systems Technologies and Services	10
Category 7- Space Environment Monitoring Technologies	1
Category 8 - Space System Project Management	7
Category 9 - Software, Programming and Computer Skills	8
Category 10 - Space Applications	1
Category 11 - Space Sector Enabling Skills	6
Category 12 - Soft Skills	0
TOTAL	**41**

The premise for the study was that there are discrete key gaps in the Australian space sector. The fact that current skills and shortages exist for almost every skill is an unexpected finding. The data indicates that all 319 Tier Three skills will be required in the future. This suggests an industry poised for growth that cannot keep up with skills demand. It also suggests there may be potential imbalances between skills capability and shortages across the Australian space industry. It further suggests there is a likely need for training and other strategies such as outsourcing and skilled migration to address current shortages and future requirements. Recruiting locally was the most stated means of acquiring skills, with training as the second most common method, followed by recruiting internationally. The study also identified that Australia's space industry is heavily engaged in outreach activities to attract new people as an important long-term strategy towards building a sizeable, suitably trained workforce.

Training providers

This study also explored providers that might be able to deliver training and skills development for space-related skills needs. A range of training options to build skills capability were explored, such as tertiary education, in house training, professional development and bespoke training programs. Some of the key findings on training providers include:

1. Of the 90 survey respondent organisations, **46 organisations** (51%), spread **across Australia**, indicated they could **provide some form of training** for space-related skills development, training, or education.

2. The largest number of training provider respondent organisations were from the private sector (46%), with 39% from the university sector, 9% from the not-for-profit sector and 7% from the government sector.

3. Providers of university undergraduate or postgraduate programs were the most frequently referred to training activity (37%), while in-house training comprised 33%, bespoke training programs 22% and industry training programs 7% of training providers. No training providers from the TAFE or vocational sector participated in the survey.

4. **Of the 86 high intensity Tier Three skills, 67% have one or no training providers** identified in the survey

(20 have no training provider identified, 38 have one training provider identified).

5. **Only 28%** of the training providers (13) have identified any **ability to deliver training for the 86 high intensity Tier Three skills**, resulting in a number of training gaps.

6. There are **25 high intensity skills** that might be **needed for SmartSat CRC research programs that have only one or no training provider.**

The data indicates **there are some potential gaps in training providers for space-related skills**. In addition, the training needs for such a large skills-set seems to rest with a handful of training providers, and often relies on in-house training programs.

The burden of training for the current skills shortages and future demand may lead to additional training provider shortages or gaps, and may require:

- more training programs, and
- more training provider capacity.

Further detailed work will be needed to identify, in more depth, the collective ability for providers to deliver sufficient training in the high intensity shortage areas and to cater for the training needs of the growing Australian space industry.

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2.0 Background and context

SmartSat was established with the vision to become a leading contributor in transforming Australia's space innovation ecosystem for the nation's future prosperity. Its mission is to conduct translational research which creates game-changing space technologies and generates know-how that will make Australian space industries more competitive and future-proof the jobs of all Australians.[1] In support of this objective, SmartSat is committed to collaborating with the broader Australian space industry to co-ordinate efforts in identifying and growing the skills necessary to support the industry into the future. In parallel with these objectives, the inspire pillar of the *Australian Civil Space Strategy 2019-2028* focuses on the future space workforce. Consequently, the Australian Space Agency seeks to target appropriate areas within its skills development programs to support this future workforce.

The nature of space activity and the shape of the space industry has been changing and will continue to evolve into the future. New capabilities, services and fields of endeavour are emerging, and the Australian space community must be prepared to take advantage of these opportunities. For Australia to achieve this, the workforce must possess and continually develop the appropriate skills to meet the growth targets set by the Australian Government - to triple the size of Australia's space industry and grow an additional 20,000 jobs by 2030. The SmartSat Education and Training College has been established to co-ordinate its efforts to develop these much-needed skills. A key initial priority for this program is to conduct a skills gap analysis of the Australian space industry.[2]

For this analysis to be effective in ensuring the appropriate capabilities of Australia's future space workforce, it needs to be built upon:

1. a solid and detailed understanding of the Australian space industry and current skills; and

2. a deep understanding of newly emerging directions and trends, including their associated skills-sets, within the global space industry.

SmartSat engaged WSU in partnership with APAC to conduct a space industry skills gap analysis. This study provides a critical first step in preparing the Australian space industry workforce for the future by identifying not only current skills shortages, but also the skills required in emerging and future areas of space commerce and technology.

2.1 Purpose and aims of the study

This study is intended to expand on the workforce gap identified in the *2018 Expert Reference Group review of Australia's Space Industry Capability*,[3] and allow SmartSat and the Australian Space Agency to target appropriate areas within their respective skills development programs.

The aim of this skills gap analysis is to:

1. provide an accurate appraisal of the workforce gap in required key skills
2. identify the gap in key skills relevant to SmartSat's three major research programs and three enabling themes

[1]SmartSat CRC Vision and Mission Statements, SmartSat CRC website, https://smartsatcrc.com/about/about-us/, accessed 11 January 2021.
[2] SmartSat CRC Newsletter, Issue 9, December 2019, page 4.
[3] Review of Australias Space Industry Capability – Report from the Expert Reference Group, March 2018

3. identify relevant gaps in soft skills, technical skills, and technology-specific skills relevant to the higher education, professional development, and vocational education sectors

4. identify areas of industry where the above skills exist, and

5. identify training providers capable of providing appropriate training to address any skills gaps.

3.0 Defining Australia's space industry

The term 'space industry' has different connotations for different groups. For some, it is limited to activities related to building and launching objects into space. Others use the term more broadly to include services derived from objects operating in space. For the purposes of this study, the WSU and APAC team worked from the definition of Australia's space industry that has been developed by the Australian Space Agency and described on its website:

> *Australia's space industry is defined as a set of space-related activities along the space value chain and is part of the broader space economy.*
>
> *All actors (private, public, and academic) participating in production, operation, supply, and enablement activities that form the space value chain are part of the space sector. Space value chain segments broadly include manufacturing and core inputs (ground and space segment manufacturing and services); space operations; space applications; and enablers (such as regulation and essential service delivery, infrastructure and capabilities, research, development and engineering, and specialised support services).*
>
> *While the space sector captures the provision of space related goods, services, and applications to broader industries, it does not include subsequent non-space (value-adding) activities that are enabled by space activities (such as food grown using precision agriculture techniques). These flow-on activities are captured by the broader space economy.*[4]

The Australian Space Agency further defines Australia's space industry value chain to broadly include four segments of activities. According to that definition, all actors (private, public and academia) participating in any activities that sit within these segments are to be considered part of the space industry. These four segments are:

1. **Manufacturing and core inputs, consisting of:**

   - **Ground segment manufacturing and services -** building and integration of ground-based facilities and equipment that perform space-related activities. Associated services, such as maintenance, are included. For example, manufacturing a satellite dish and control facility that will receive data from, and transmit to, a satellite.

   - **Space segment manufacturing and services -** building and integration of items to go into space, including spacecraft, satellites, payloads, and products to be used in space. For example, manufacturing a satellite that will perform earth observation.

2. **Space operations**

   Launch activities, the management of objects in space, and activities associated with using and managing satellites in space. Also includes operations and remote operations conducted in space. For example, launching the satellite into space, monitoring space debris, or providing instructions to a satellite to capture earth observation images.

3. **Space applications**

   Use of space-derived resources to create products and services, including software, hardware, and

[4] Defining the Australian Space Sector, Australian Space Agency website, https://www.industry.gov.au/data-and-publications/definition-of-the-australian-space-sector/defining-the-australian-space-sector, accessed 11 January 2021.

publications, and services provided across the economy. Further, the application of space technologies and data to improve other areas of the economy. For example, producing the hardware and software to process earth observation imagery or direct-to-home television (DTH TV).

4. **Enablers**

The Australian Space Agency also describes activities that are **enablers,** consisting of:

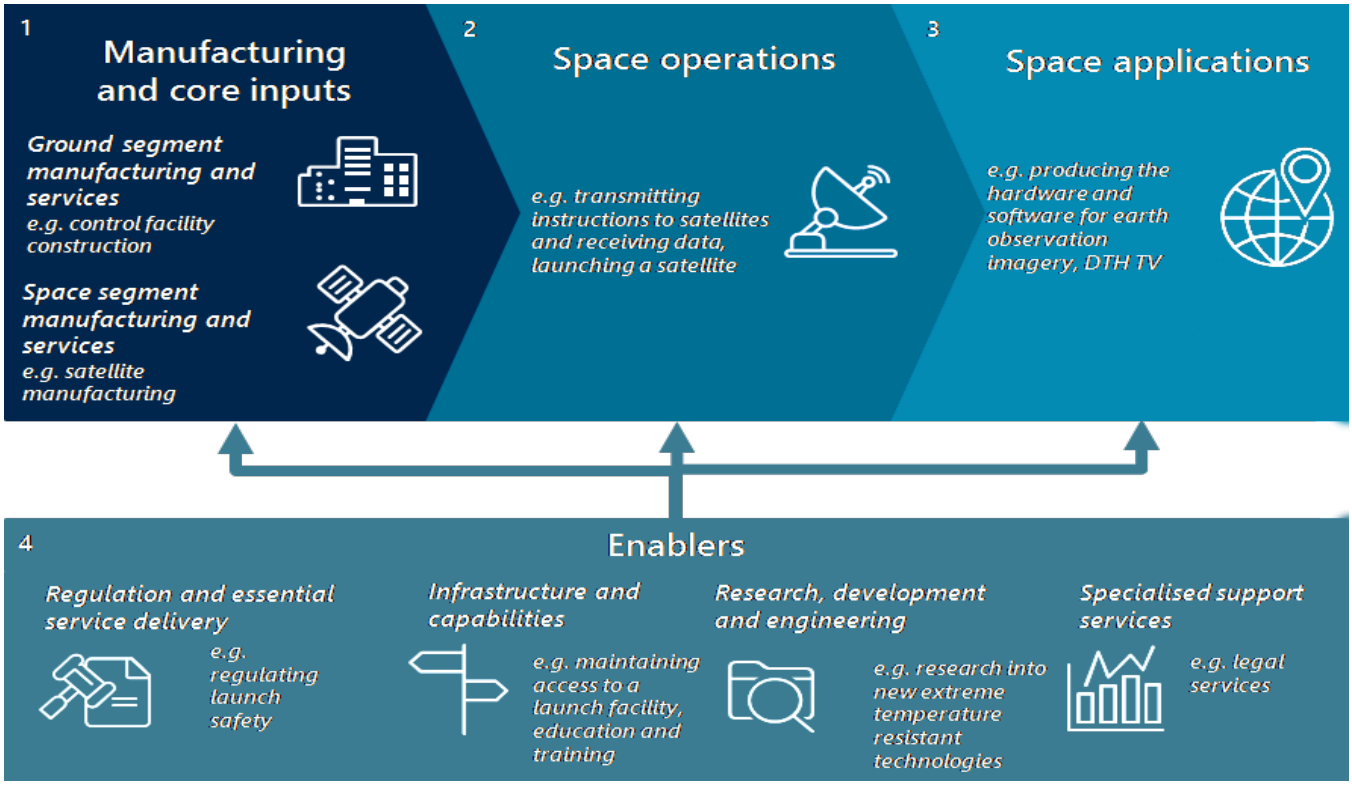
- **Regulation and essential service delivery** - Policy and regulatory enablers of the entire space sector. For example, regulating launch safety.
- **Infrastructure and capabilities -** Infrastructure, both physical and intangible, that supports the entire space sector. Development of capabilities relevant to, and supporting, the space sector. For example, roads and utilities that service a remote launch facility or education in engineering disciplines to operate satellites.
- **Research, development, and engineering -** support for the activities of the space sector, including experimental and exploratory research, and testing and refining technologies. For example, research into new extreme temperature-resistant technologies or new data transfer processes.
- **Specialised support services -** these directly contribute to, and enable, the activities that comprise the space industry. For example, a law firm that specialises in space law to help a launch operator manage its space-related activity and legal compliance.

Value chain of the space sector

Together these four segments comprise the space sector value chain defined by the Australian Space Agency and depicted in Figure 1 below.[5]

[5] Activities Included in the Space Sector, Australian Space Agency Website, https://www.industry.gov.au/data-and-publications/definition-of-the-australian-space-sector/activities-included-in-the-space-sector, accessed 11 January 2021.

Figure 1 Value Chain of the space sector



This definition is consistent with the definitions of the space industry used in major national and international studies worldwide.

4.0 Definition and categorisation of space industry skills groups

4.1 Development of an Australian Space Skills Taxonomy (ASST)

A fundamental step in analysing space industry skills and needs is to develop a taxonomy that encompasses all elements of the Australian space industry - as defined by the Australian Space Agency in the previous section - and provides sufficient depth to identify relevant skills. The WSU and APAC team used the foundational concepts behind existing skills taxonomies and applied them to develop a taxonomy appropriate for Australian space-related skills.

Extensive research reveals there is no comprehensive job skills taxonomy for the space industry. Most skill categorisations are based on occupations rather than skills, for example, the Australia New Zealand Standard Classification of Occupations or ANZSCO. None of these major categorisations include space-related occupations or skills as a discrete category.

Some skills-focused taxonomies exist, such as the UK Space Skills Alliance Taxonomy, but are structured around employment. These taxonomies have typically been developed using job advertisements to identify the range of skills required. They tend to only identify skills at a high level and highlight job traits rather than actual skills. Moreover, they do not provide a comprehensive representation of the range and depth of space-related job skills needed for this study, which requires greater subtlety and tailoring to identify current and future job skills, as well as research and development capabilities across SmartSat research programs and the broader Australian space industry. Consequently, the WSU and APAC team have used the foundational concepts behind existing job skills taxonomies and refined them to develop the ASST.

International job skills taxonomies addressing the high-tech sector were considered and reviewed.[6] Each use a hierarchical structure and incorporate similar high-level skills groupings such as:

- technical skills - such as welding, software development, and financial analysis
- software skills - such as use of Adobe Photoshop, Structured Query Language (SQL,) and AutoCAD
- baseline (soft) skills - such as communication, problem-solving, and creativity.

or

- foundational skills
- analytical skills
- technical skills
- resource management skills
- interpersonal skills.

Starting with this general hierarchical structure as used in high tech sector taxonomies, the WSU and APAC team reviewed specific information on the space sector to identify the appropriate skills and hierarchy, including the

[6] The WSU / APAC team reviewed the below documents in the development of the ASST: *Mapping the Genome of Jobs: The Burning Glass Skills Taxonomy*, Burning Glass Technologies, September 2019; J Djumalieva and C Sleeman, *Making Sense of Skills: A UK Skills Taxonomy*, NESTA 2018; *National Occupational Classification: Skills*, online resource, Government of Canada website, https://noc.esdc.gc.ca/SkillsTaxonomy/Skills/480d44479925499da75042c30255d9e2, updated 2020-12-02;
1220.0 – ANZSCO – Australian and New Zealand Standard Classification of Occupations Version 1.3, online resource, Australian Bureau of Statistics, https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/1220.02013,%20Version%201.3?OpenDocument, updated 5 November 2019.

ESA Technology Tree[7], the ESA Generic Product Tree[8], the NASA Technology Taxonomy[9] and the UK Space Skills Alliance Taxonomy.[10]

The WSU and APAC team then built a three-tier space skills taxonomy. It utilises the concepts of the Australian Space Agency definition of space and activities included in the Australian space industry, the key tenets of SmartSat research program themes and enablers as well as previous APAC work on the characterisation of the Australian space sector to specifically tailor this generic taxonomy to suit the Australian context and the purposes of this study. This proposed taxonomy was then reviewed by select researchers within SmartSat and participants in the broader industry to provide a measure of validation.

The resulting ASST is fairly detailed. It is a three-tier hierarchical taxonomy tailored to the specific characteristics of currently needed or used Australian space-related skills with sufficient detail to allow a gap analysis to be conducted.

Soft skills - definition and terminology

The term 'soft skills' relates to personal abilities that improve human performance and facilitate effective interactions amongst people.

Studies reveal that soft skills based in writing, listening, and communicating are actually more accurate predictors of long-term career success for STEM-based professions and roles than their technical skills and qualifications.[11] There is significant evidence to indicate that the new generations of graduates and workers require inspiring and engaging leaders, often not traditionally expected in the stereotypical technical leader. Hence there is a need for modern space sector leaders to have greater awareness and insight as to how their leadership behaviours contribute to the attraction, recruitment, and retention of staff as well as staff engagement and productivity in the workplace. There is also evidence that many STEM graduates have strong technical skills but are not workplace ready as they do not have the skills to manage the interpersonal aspects of the workplace[12] [13] [14].

With all these factors in mind, the WSU and APAC team considered soft skills in two broad skills groups related to facilitating effective interactions with people, and harnessing people's talents to achieve desirable task and organisational outcomes:

1) Communication skills – written and verbal:
   a) Interpersonal skills – teamwork, collaboration, relationship building, conflict management, working with diversity
   b) Leadership skills – inspiring others, 'walking the talk', effective performance management, effective delegation, developing others
   c) Influencing and persuasion skills – influencing to achieve outcomes, effective negotiation for resources,

[7] *ESA Technology Tree, version 4.0*, European Space Agency (ESA) Communications, April 2020.
[8] *ESA Generic Product Tree, version 1.0*, European Space Agency (ESA), July 2011.
[9] *NASA Technology Taxonomy*, National Aeronautics and Space Administration (NASA), 2020.
[10] J Dudley and H Thiemann, *Towards a Space Competencies Taxonomy*, Space Skills Alliance, May 2020.
[11] Yao, C.W. and Tuliao, M.D. (2019), 'Soft skill development for employability: A case study of stem graduate students at a Vietnamese transnational university', Higher Education, Skills and Work-Based Learning, Vol. 9 No. 3, pp. 250-263. https://doi.org/10.1108/HESWBL-03-2018-0027
[12] R. Razdan, R. Polanco, Z. Ackerman, X. Vidot and D. Razdan, 'GANDALF: A Real-World Solution to the 'Soft Skills' Problem for Engineering Careers,' 2019 IEEE Technology and Engineering Management Conference (TEMSCON), Atlanta, GA, USA, 2019, pp. 1-5, doi: 10.1109/TEMSCON.2019.8813665.
[13] L. Hickman and M. Akdere, 'Exploring Virtual Reality for Developing Soft-Skills in STEM Education,' 2017 7th World Engineering Education Forum (WEEF), Kuala Lumpur, Malaysia, 2017, pp. 461-465, doi: 10.1109/WEEF.2017.8467037.
[14] Wikle, T.A. and Fagin, T.D. (2015), Hard and Soft Skills in Preparing GIS Professionals: Comparing Perceptions of Employers and Educators. *Transactions in GIS*, 19: 641-652. https://doi.org/10.1111/tgis.12126

pricing contracts.

2) Skills related to personal abilities that improve performance in the workplace:
   a) Self-management – resilience, emotional intelligence, setting boundaries, work/life balance, wellbeing (physical and psychological), workload management
   b) Creative thinking – innovation, thinking outside the square
   c) Adaptability – taking perspective, growth mindset, lifelong learning, flexible thinking
   d) Decision making and problem solving – critical thinking, abstract reasoning, locating and synthesising information, timely problem solving.

Given the growing evidence of the importance of soft skills in the modern workplace, the WSU and APAC team developed a three-tier structure consistent with the rest of the taxonomy and based around the above two broad aspects of soft skills. This section is designated as Tier One Skills, Category 12, Soft Skills.

4.2 Skills Relevant to the broader Australian space industry

As noted above, the ASST is based on a hierarchical structure. It incorporates 12 high level (Tier One) categories of skills, which are then broken down into sub-groupings (Tier Two) and further subcategories of skills (Tier Three). Across this structure there are 56 Tier Two Skills Groups and 319 Tier Three Skills relevant to the broader Australian space industry. The Tier One Skills categories and Tier Two Skills Groups are shown in Table 3.

Table 3 Tier One skills Categories and Tier Two Skills Groups

Tier 1 Skils Category	Tier 2 Skills Group		Tier 2 Skills Group	
1	**Launcher and Spacecraft Development Skills**			
	1.1	Propulsion Systems	1.4	Space Systems Electrical Power
	1.2	Flight Computing and Avionics	1.5	Thermal Management Systems
	1.3	Guidance, Navigation & Control	1.6	Fluid Dynamics
2	**Satellite Payload and Sensor Development Skills**			
	2.1	On-Board Data Subsystems	2.2	Sensors & Instruments
3	**Satellite Payload and Ground Based Technologies Development Skills**			
	3.1	RF Subsystems, Payloads and Technologies	3.4	Optoelectronics
	3.2	Electromagnetic Technologies & Techniques	3.5	Position, Navigation & Timing Technologies
	3.3	Optics	3.6	Internet of Things Technologies
4	**Space Exploration Technologies Development Skills**			
	4.1	Robotic Systems	4.4	Entry, Descent & Landing
	4.2	Autonomous Systems	4.5	In-Situ Resource Utilisation
	4.3	Planetary Body Exploration	4.6	Human Health, Life Support & Habitation Systems
5	**Spacecraft Mechanisms Structures & Materials Development Skills**			
	5.1	Mechanisms		
	5.2	Structures		
	5.3	Materials and Manufacturing Processes		
	5.4	Electrical, Electronic and Electro-mechanical (EEE) Components and Quality		
6	**Ground Systems Technologies & Services Skills**			
	6.1	Ground Station Systems and Networks		
	6.2	Mission Operations and Ground Data Systems		
	6.3	Ground, Test & Surface Systems		
7	**Space Environment Monitoring Technologies Skills**			
	7.1	Space Systems Environments and Effects	7.2	Space Situational Awareness
8	**Space System Project Management Skills**			
	8.1	Management of Space Projects	8.3	Quality, Dependability and Safety
	8.2	Systems Design & Verification		
9	**Software, Programming & Computer Skills**			
	9.1	Software used with Space Systems		
	9.2	Remote sensing /Earth Observation Software		
	9.3	Software, Modelling, Simulation & Information Processing		
	9.4	Flight Dynamics and GNSS		
	9.5	Artificial Intelligence & Machine Learning	9.7	Quantum Computing Technologies
	9.6	Virtual Reality Technologies	9.8	CyberSecurity & Resilience Technologies
10	**Space Applications Skills**			
	10.1	Satellite Communications Services & Applications		
	10.2	Earth Observation Services & Applications		
	10.3	Global Positioning, Navigation and Timing Services & Applications		
	10.4	Other Space Applications		
11	**Space Sector Enabling Skills**			
	11.1	Regulation and essential service delivery	11.3	Space Related R&D and Engineering
	11.2	Space Education and Outreach	11.4	Specialised Support Services
12	**Soft Skills**			
	12.1	Communication Skills	12.5	Influencing and persuasion skills
	12.2	Interpersonal skills	12.6	Creative thinking
	12.3	Leadership	12.7	Adaptability
	12.4	Self-management	12.8	Decision making & Problem-Solving

4.3 Skills relevant to SmartSat

SmartSat is pursuing its goals of creating game-changing space technologies and space know-how that will make the Australian space industry more competitive through three major integrated research programs:

1) Advanced Communication, Connectivity and IOT Technology
2) Advanced Satellite Systems, Sensors, and Intelligence, and
3) Next Generation Earth Observation Data Services.

These major programs are supported by three fundamental enablers:

1) Artificial Intelligence
2) Security and Resilience, and
3) Space Governance.

Given this specific focus, not all skills identified in the ASST are applicable, or have relevance, to SmartSat activities. To identify the relevant skills, SmartSat and the WSU and APAC team conducted an analysis of the three SmartSat research programs, associated projects and activities, and the three enabling themes, and identified applicable skills from the ASST.

This analysis found that, while all 12 Tier One Skills categories were relevant to SmartSat, only 158 of the Tier Three skills (out of a total of 319) were relevant, based on a combined aggregate across all research programs and enabling themes.

The relevant skills for each research program and enabling theme are much more concentrated and specific. Table 4 below shows the Tier Two skills groups that are relevant to SmartSat as a whole, as well as for each of its research programs and enabling themes.

Table 4 indicates that all 12 Tier One Skills categories are relevant to at least one of the key SmartSat research programs. Table 4 is colour-coded to highlight the Tier Two Skills Groups relevant to each SmartSat CRC research program or enabling theme. The coding is used in the first column to indicate the level of intensity for a particular Tier Two Skills Group across all programs or themes. The lighter colour shades indicate that only one program or theme requires that skills group, while the darkest colour indicates that all require that skills group.

An analysis of Table 4 shows that the below Tier Two Skills Groups are required by all SmartSat research programs and enabling themes:

- 8.1 Management of Space Projects
- 11.2 Space Education and Outreach
- 11.4 Specialised Support Services
- Category 12 – Effective Interactions Among People (Soft Skills) – all Tier Two Skills Groups.

Three of these Tier Two skills groups - Management of Space Projects, Specialised Support Services, and Soft Skills - are widely recognized as essential across the space industry. Space Education and Outreach is particularly relevant to SmartSat; hence it is not surprising that the research programs and enabling themes need these particular skills groups.

The below Tier Two skills groups are required by five of the six combined research programs and enabling themes:

- 8.2 Systems Design and Verification
- 8.3 Quality, Dependability and Safety
- 9.3 Software, Modelling, Simulation, and Information Processing
- 11.3 Space-Related R&D and Engineering

Three of these Tier Two skills groups – Systems Design and Verification; Quality, Dependability and Safety; and Software, Modelling, Simulation and Information Processing – are also widely recognized as essential skills groups for many space industry projects. The Space-Related R&D and Engineering Skills group is also particularly relevant to SmartSat and its strong R&D focus. It is not surprising that nearly all its programs and enabling themes need these skills groups.

Table 4 Skills groups relevant to SmartSat

Tier 1 Skills Category		Tier 2 Skills Group	Number of SmartSat CRC Research Programs or Enabling Themes requiring the skills	Advanced Communications, Connectivity & IoT Technologies	Advanced Satellite Systems, Sensors and Intelligence	Next Generation Earth Observation Data Services	Artificial Intelligence	Security and Resilience	Space Governance
1		**Launcher and Spacecraft Development Skills**							
	1.1	Propulsion Systems	1		●				
	1.2	Flight Computing and Avionics	1		●				
	1.3	Guidance, Navigation & Control	1		●				
	1.4	Space Systems Electrical Power							
	1.5	Thermal Management Systems							
	1.6	Fluid Dynamics							
2		**Satellite Payload and Sensor Development Skills**							
	2.1	On-Board Data Subsystems	3	●	●	●			
	2.2	Sensors & Instruments	2		●	●			
3		**Skills**							
	3.1	RF Subsystems, Payloads and Technologies	2	●	●				
	3.2	Electromagnetic Technologies & Techniques	2	●	●				
	3.3	Optics	2	●	●				
	3.4	Optoelectronics	2	●	●				
	3.5	Position, Navigation & Timing Technologies							
	3.6	Internet of Things Technologies	2	●		●			
4		**Space Exploration Technologies Development Skills**							
	4.1	Robotic Systems							
	4.2	Autonomous Systems	1		●				
	4.3	Planetary Body Exploration	1						●
	4.4	Entry, Descent & Landing							
	4.5	In-Situ Resource Utilisation							
	4.6	Human Health, Life Support & Habitation Systems							
5		**Spacecraft Mechanisms Structures & Materials Development Skills**							
	5.1	Mechanisms	1		●				
	5.2	Structures							
	5.3	Materials and Manufacturing Processes	2	●	●				
	5.4	Electrical, Electronic and Electro-mechanical (EEE) Components and Quality	2	●	●				
6		**Ground Systems Technologies & Services Skills**							
	6.1	Ground Station Systems and Networks	1	●					
	6.2	Mission Operations and Ground Data Systems	1	●					
	6.3	Ground, Test & Surface Systems	2	●		●			
7		**Space Environment Monitoring Technologies Skills**							
	7.1	Space Systems Environments and Effects							
	7.2	Space Situational Awareness	1						●
8		**Space System Project Management Skills**							
	8.1	Management of Space Projects	6	●	●	●	●	●	●
	8.2	Systems Design & Verification	5	●	●	●	●	●	
	8.3	Quality, Dependability and Safety	5	●	●	●	●	●	
9		**Software, Programming & Computer Skills**							
	9.1	Software used with Space Systems	4	●	●	●	●		
	9.2	Remote sensing /Earth Observation Software	1			●			
	9.3	Software, Modelling, Simulation & Information Processing	5	●	●	●	●	●	
	9.4	Flight Dynamics and GNSS							
	9.5	Artificial Intelligence & Machine Learning	4	●	●	●	●		
	9.6	Virtual Reality Technologies	1			●			
	9.7	Quantum Computing Technologies	2	●	●				
	9.8	CyberSecurity & Resilience Technologies	3	●	●	●		●	
10		**Space Applications Skills**							
	10	Satellite Communications Services & Applications	2	●	●				
	10	Earth Observation Services & Applications	2		●	●			
	10	Global Positioning, Navigation and Timing Services & Applications							
	10	Other Space Applications							
11		**Space Sector Enabling Skills**							
	11	Regulation and essential service delivery	1						●
	11	Space Education and Outreach	6	●	●	●	●	●	●
	11	Space Related R&D and Engineering	5	●	●	●	●	●	
	11	Specialised Support Services	6	●	●	●	●	●	●
12		**Soft Skills**							
	12	Communication Skills	6	●	●	●	●	●	●
	12	Interpersonal skills	6	●	●	●	●	●	●
	12	Leadership	6	●	●	●	●	●	●
	12	Self-management	6	●	●	●	●	●	●
	13	Influencing and persuasion skills	6	●	●	●	●	●	●
	13	Creative thinking	6	●	●	●	●	●	●
	13	Adaptability	6	●	●	●	●	●	●
	13	Decision making & Problem-Solving	6	●	●	●	●	●	●

5.0 Methodology

This study was undertaken using a combination of desktop research, an online survey instrument (described below), and selected direct interviews with companies, research institutions and universities involved in the Australian space industry. The data collected was analysed to determine:

- Current skills employed
- Current skills shortages
- Anticipated future skills requirements, and
- Training and education providers for each skill

across the broader Australian space industry, as well as areas of most relevance to SmartSat.

Sensitivity analyses were undertaken to identify likely skills needs and training and education gaps so that high priority areas for skills development programs could be identified for further in-depth study and quantification.

5.1 The online survey

The online survey instrument included relevant questions used in previous studies conducted by APAC on Australia's space industry for the Australian Government to capture demographic data, organisational information, areas of space activity and skills shortages, in order to build upon previous findings and emerging trends. As noted above, a detailed ASST was developed, and this was included in the survey to obtain the required level of detail on job skills and needs.

The survey comprised 126 questions covering the below key areas:

- Nine demographic questions:
    - six questions on demographic information - such as name, location, sector, and size of respondent organisations
    - three questions on segments that the respondents' activities fall into:
        - nine Australian space sector segments used in previous studies by APAC to provide longitudinal data for this study
        - SmartSat's three major research programs and/or three enabling themes
        - the Australian Space Agency's seven National Civil Space Priority Areas
- 104 questions related to the ASST:
    - one question about the twelve Tier One skills categories where the organisation has current or future skills requirements
    - 56 questions related to each of the Tier Two skills groups enabling an indication for each of the Tier Three skills whether the organisation:

- employs people with those skills
- experiences a shortage of those skills
- anticipates those skills being required in the future
- is a provider of training or education to develop those skills.

- 24 text responses to obtain information for each Tier One Category regarding:
  - currently required skills for the organisation's space-related activities in that skills category that may not be covered in the ASST
  - skills that the organisation anticipates will be required in the future or their space-related activities in that skills category that may not be covered in the ASST.
- 24 questions to navigate between the skills categories that generated no data for the study
- four skills gap management questions covering:
  - how the organisation handles skills shortages
  - what skills they recruit from overseas and which countries they recruit from.
- six training and education provider questions covering:
  - types of training and education providers necessary to develop space industry skills – for example, universities, in-house learning and development (L and D)
  - current training and education programs
  - plans for future training and education programs.
- two questions about outreach activities:
- two open-ended questions to enable organisations to make general comments about:
  - current skills shortages, in Australia's space industry, and how they could be addressed
  - future skills requirements in Australia's space industry, and how they could be addressed.

5.2 Survey distribution

The survey was distributed widely throughout the Australian space community via a number of mechanisms. The survey was established with four collectors, each with a separate link as set out below, to identify the source of survey responses:

1. SmartSat CRC link – sent to the 113 members of SmartSat

2. SmartSat CRC associate link –used to invite colleagues and associates of SmartSat members to access the survey.

3. APAC link –used to invite some 200 APAC clients and associates that were not members of SmartSat or their colleagues. This link was also distributed by the NSW Government to invite its space industry contacts to complete the survey.

4. SIAA Link – used by the Space Industry Association of Australia (SIAA) to invite its members to complete the survey.

The survey was open for 31 days from 10 November to 10 December 2020. Weekly reminders were sent via email during that period to encourage broad participation in the survey.

6.0 Survey response demographics

6.1 Survey responses

A total of 119 organisations responded, of which 90 provided sufficient meaningful data for use in the study. The responses came from:

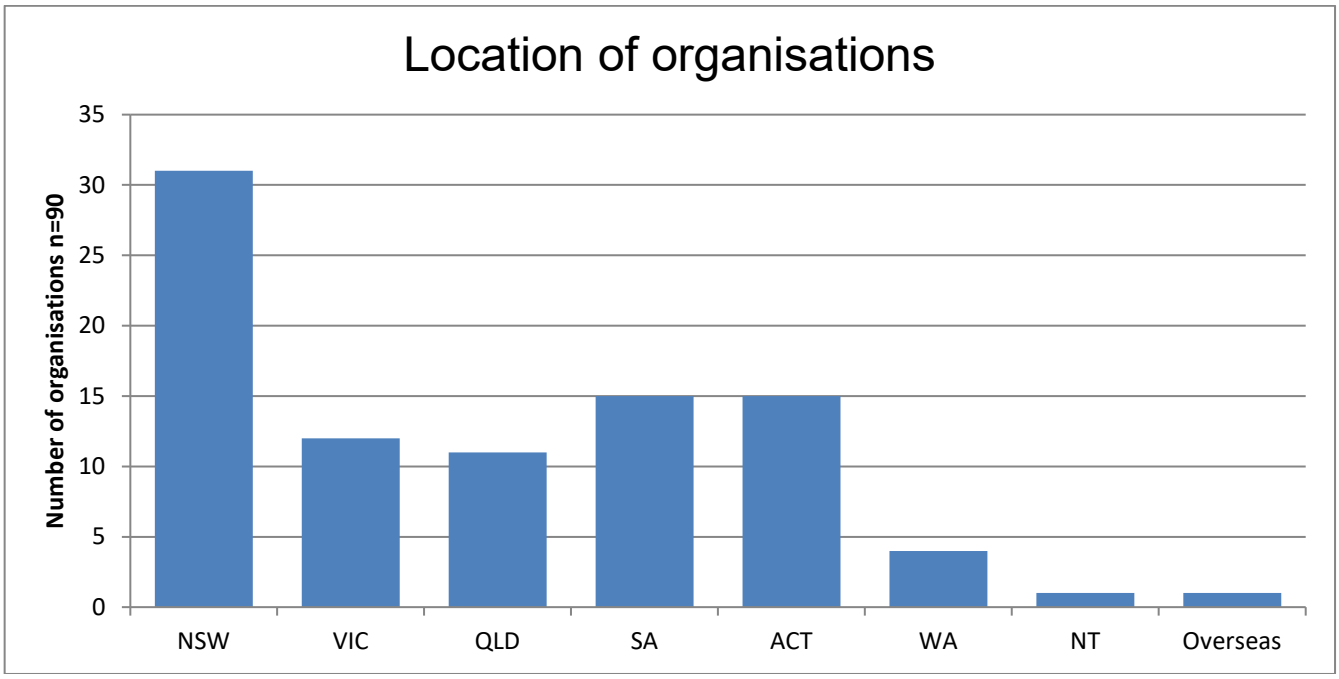
Table 5 Breakdown of usable survey responses

Survey respondents	Usable surveys	surveys with insufficient data	TOTAL RESPONSES
Responses from SmartSat CRC members	41	15	56
Responses from the broader Australian space community	49	14	63
TOTAL	**90**	**29**	**119**

6.2 Respondent organisations by location

As indicated in Table 6, 89 respondents were from Australian based organisations, and one from overseas. The largest proportion (34%) of these organisations are in NSW. This pattern corresponds closely to the profile of concentration of space organisations by state, as ascertained from previous APAC studies that show that NSW has the largest number of space organisations in Australia, followed by SA and the ACT.

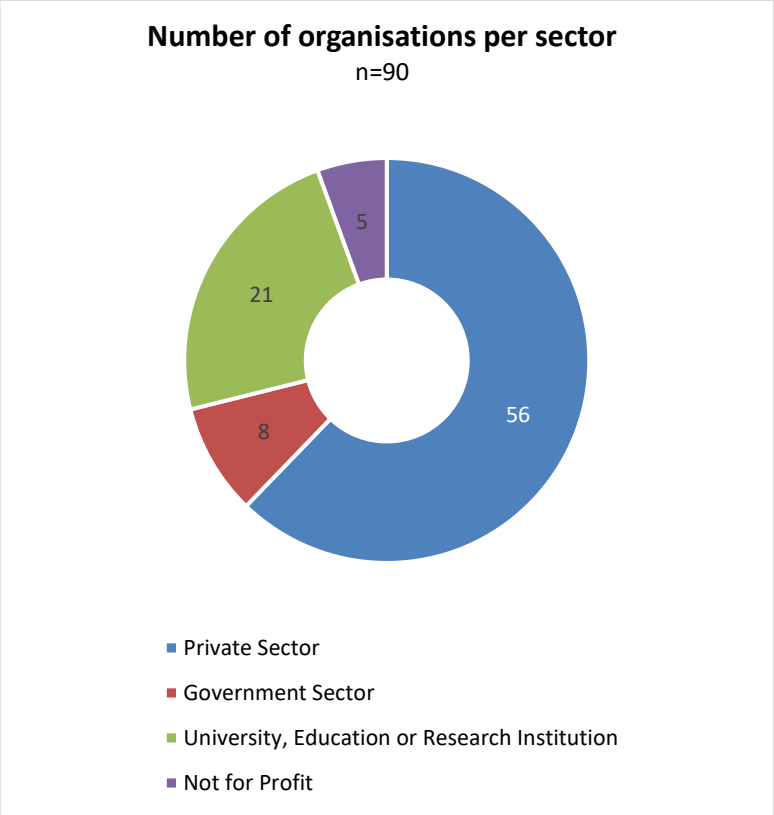
Table 6 Location of survey respondent organisations



6.3 Respondent organisations by sector

As shown in the graph below, the majority of the 90 organisations responding to the study (63%) were from the private sector, and 23% were from the university or research sector. There was minimal representation from government (9%) and the not-for-profit (6%) sector. This distribution is similar to proportions in previous APAC surveys, where the private sector and the university /research sector comprise the two largest elements of the Australian space sector.

Figure 2 Survey respondent organisations by sector



6.4 Respondent organisations by size

Organisational size was indicated in two ways – by number of employees and by revenue, as indicated in Figure 3 and Figure 4. It should be noted that the space industry vernacular often categorises organisations as multinationals, primes, or small-medium enterprises (SMEs) when referring to the size and status of an organisation. However, these terms are not recognised or used by the Australian Bureau of Statistics (ABS) or the Australian Tax Office (ATO). The ABS instead uses the below terms to describe organisations by staff numbers:

- Large organisations (more than 200 employees)
- Medium organisations (20-199 employees)
- Small organisations (5-19 employees)
- Micro organisations (0-4 employees)

The ATO uses the below terms to describe organisations by revenue:

- Large organisations (annual revenue greater than A$250 million)
- Medium organisations (annual revenue between A$10 million to A$250 million)
- Small organisations (annual revenue less than A$10 million)

For the purposes of this study, the WSU and APAC team used the ABS terms to characterise organisations by size and revenue rather than the common industry vernacular to enable a direct comparison with ABS and ATO data from other industries.

In terms of size measured by staff numbers, analysis of the data shows that large organisations comprised 39% of the 90 respondents. medium organisations and small organisations each comprised 20%, while micro-organisations comprised 21% of respondents as indicated in Figure 3.

In terms of size measured by revenue, the data shows that the pattern is reversed, with small organisations comprising 51% of the 90 respondents, large organisations 26% and medium organisations 21% as indicated in Figure 4.

These figures suggest there are many space-related respondent organisations with relatively large numbers of staff that have smaller revenue than typical large organisations in Australia. The fact that most respondents are small organisations in terms of revenue is consistent with previous APAC studies, which have indicated that most Australian space organisations are small or medium enterprises or small divisions within a larger organisation.

Figure 3 Respondent organisation size in terms of Australian employees

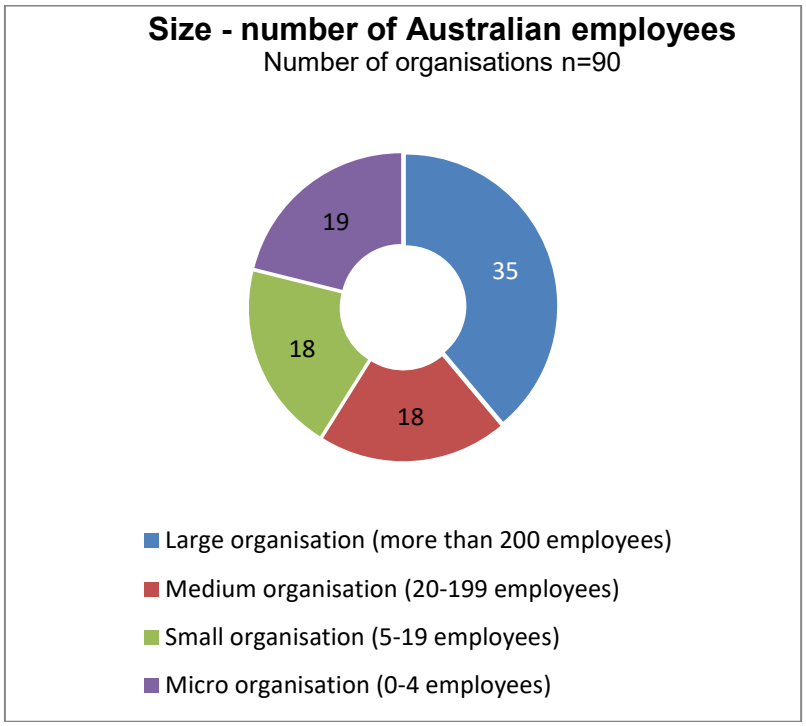
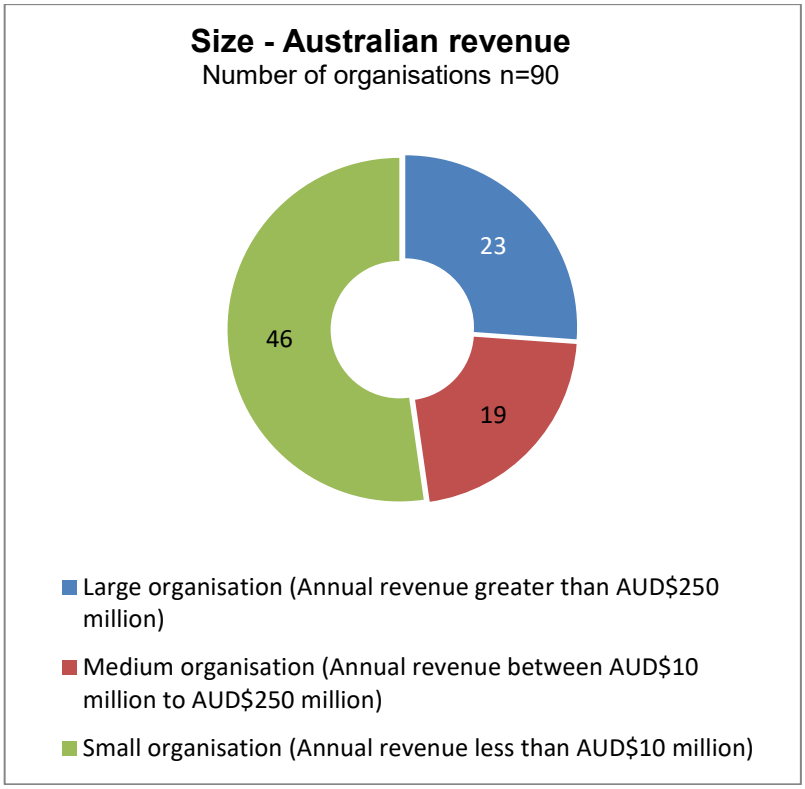


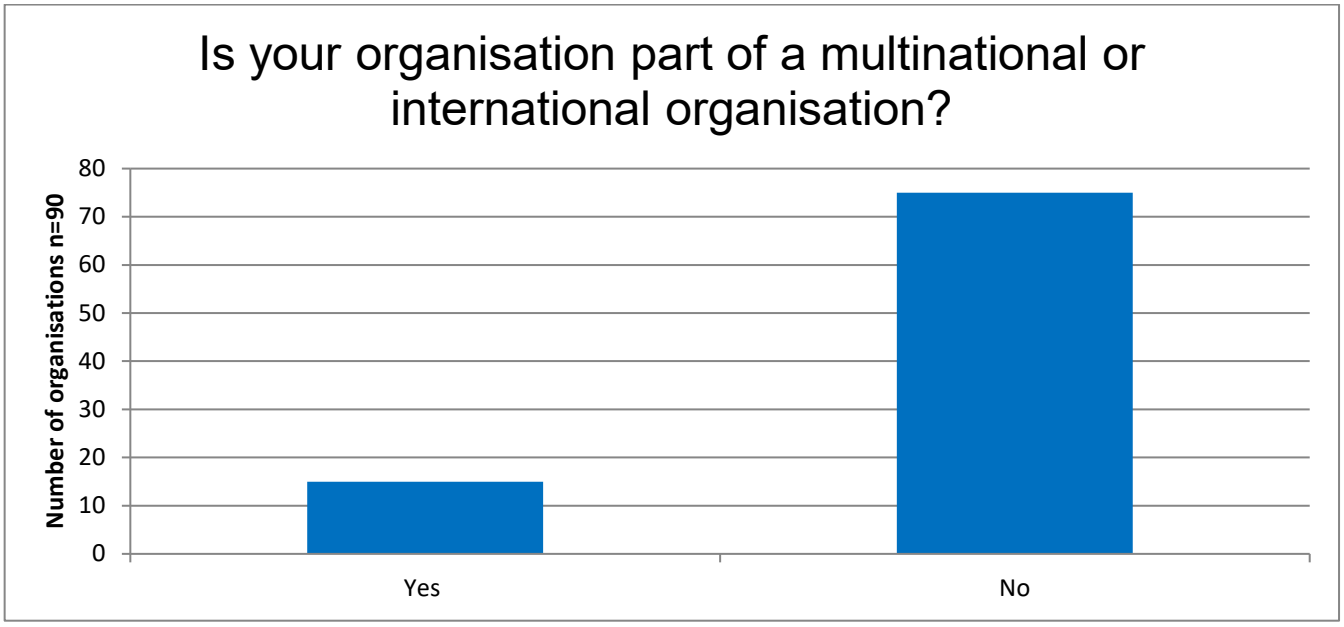
Figure 4 Respondent organisation size in terms of Australian revenue



6.5 Multinationals

Only 15 of the 90 respondent organisations (17%) indicated that they were part of a multinational or overseas organisation. Multinationals were requested to limit their responses to their Australian operations. The vast majority of respondents (83%) were Australian organisations based in Australia.

Table 7 Multinational organisations as a proportion of survey respondents



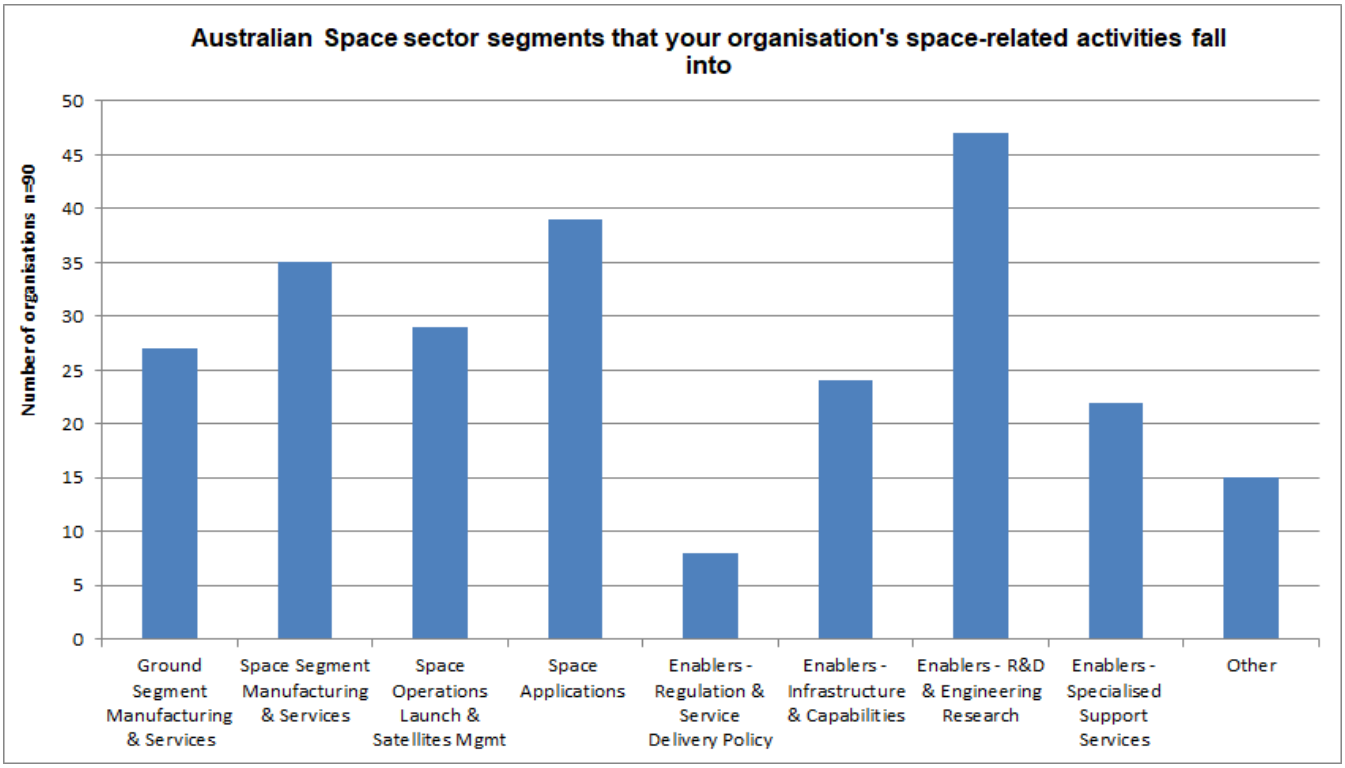
6.6 Space sector segments

Three questions asked respondents to indicate their space-related activity sectors. As indicated in Figure 5, all segments of the Australian space industry are well represented in the study.

6.6.1 Australian space sector segments

Participants were asked to indicate each of Australia's space industry segments that their Australian activities fell into. The segments are based on the Australian Space Agency definition of activities in the space sector as described under section 3.0 Defining Australia's space industry.
There were three questions asking respondents to indicate the types of space-related activity sectors in which their organisations participated.

Figure 5 Respondent organisations by Australian space sector segment



6.6.2 SmartSat activity alignment

Participants were asked to indicate any of their organisations space-related activities that fall into SmartSat's three major research programs and/or three enabling themes. These were described as follows:

- **Research Program One** - Advanced Communications, Connectivity and IoT Technologies - new technologies, signal processing algorithms and communications architectures to ensure that Australia meets its needs for universal digital connectivity - e.g. quantum cryptography and next-generation IoT architectures.

- **Research Program Two -** Advanced Satellite Systems, Sensors and Intelligence, Significant Processing and Artificial Intelligence (AI) - techniques to carry out advanced analytics on-board

satellites to enhance the efficiency and effectiveness of data gathering and analysis - e.g. quantum sensors, self-healing satellite systems and on-board machine learning.

- **Research Program Three** - Next Generation Earth Observation Data Services - generation of higher resolution, higher frequency image data from sensors and high-resolution real-time video to monitor our land, oceans, and environment in real time - e.g., earth observation data fusion architectures, hyperspectral sensing algorithms.

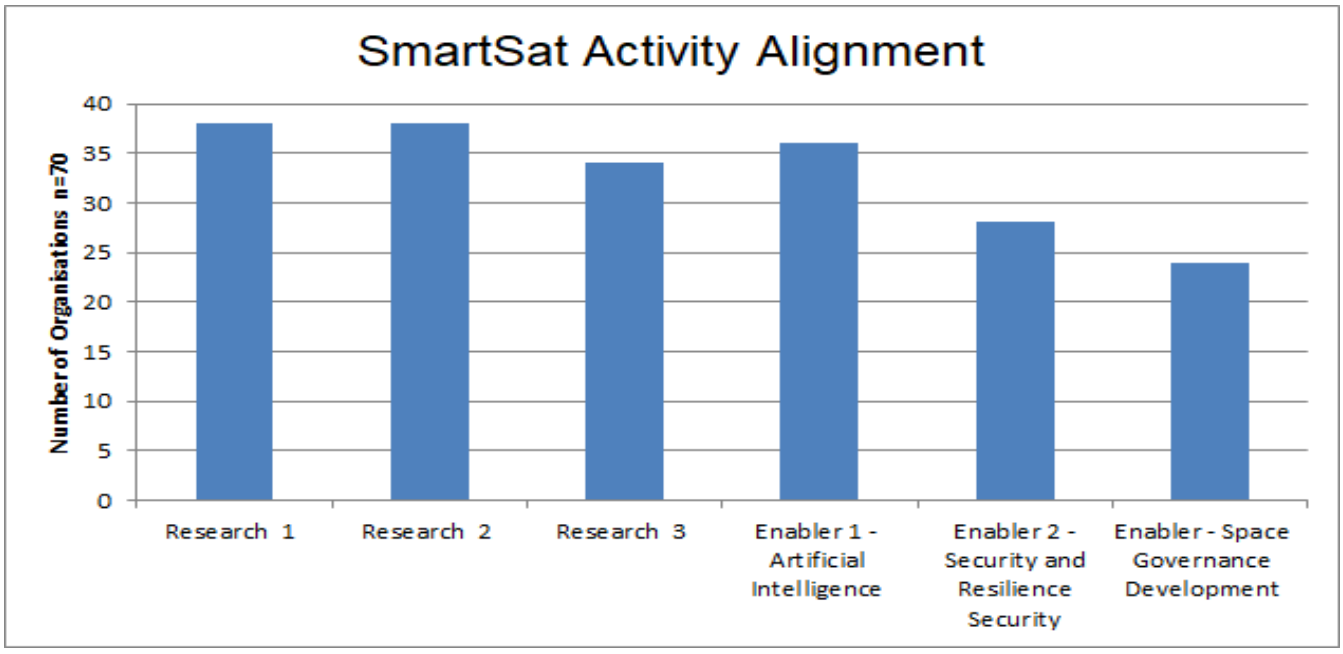
- **Enabler 1** - Artificial Intelligence - techniques relevant to space applications

- **Enabler 2** - Security and Resilience Security - includes cybersecurity and fault-tolerant quick recovery techniques adaptable to space.

- **Enabler 3** - Space Governance Development - safety concepts, procedures and standards, codes of conduct, regulations etc. for space operations.

Seventy of the 90 participating organisations (78%) indicated they had space-related activities that fell into SmartSat's three major research programs and/or enabling themes. As indicated in Figure 6, 34 (38%) to 38 (42%) of respondent organisations aligned with each research program, and 24 (27%) to 36 (40%) aligned with the three enabling themes. This suggests SmartSat is well placed to source skills in the industry for its initiatives and to cross-fertilise capability building by offering programs that develop skills in these areas.

Figure 6 Alignment of survey respondents with SmartSat activity



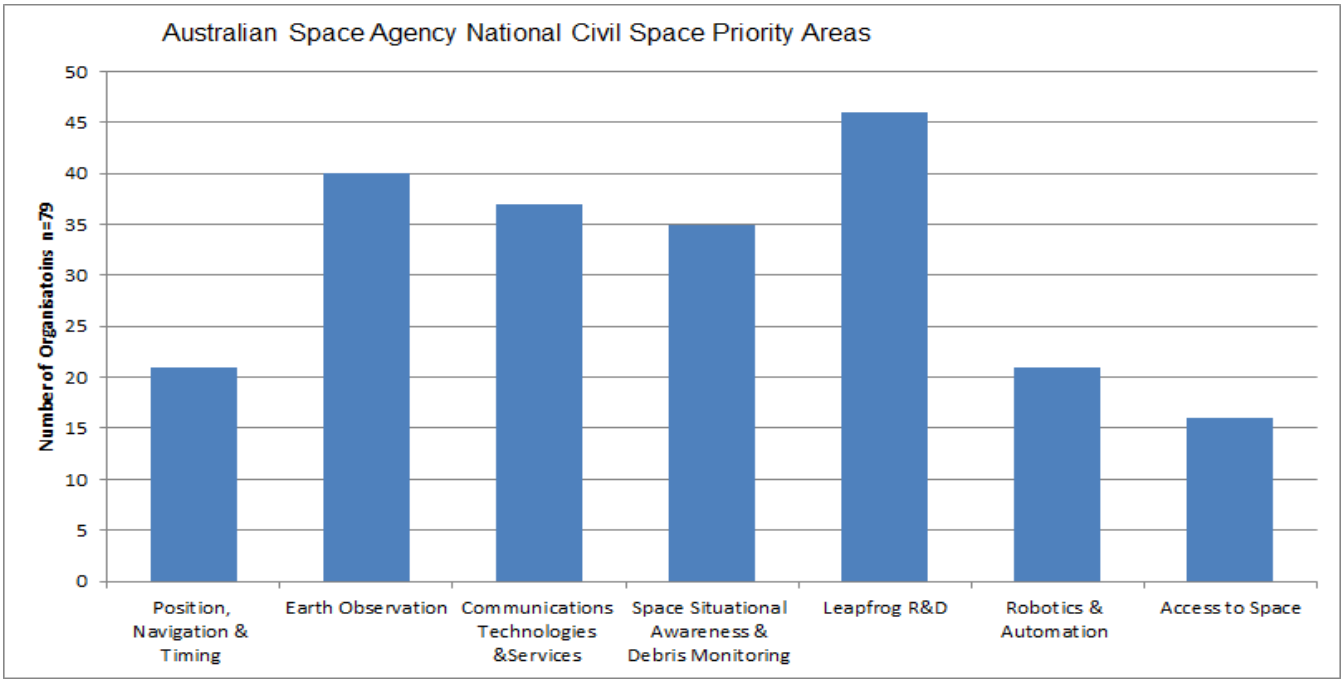
6.6.3 Australian Space Agency National Civil Space Priority Areas

Respondents were asked to indicate if any of their organisation's space-related activities fall into these priority areas:

- **Position, Navigation and Timing -**ensuring a world class Positioning, Navigating and Timing (PNT) infrastructure for Australia

- **Earth Observation** leverage Australia's world-leading strength to grow the broader economy
- **Communications Technologies and Services** - playing a lead role in emerging technologies for secure and cutting-edge land, marine, and aerospace communications
- **Space Situational Awareness and Debris Monitoring** - mitigating the risks of collisions in space
- **Leapfrog R&D** - developing and commercialising R&D to grow and transform Australia's space sector
- **Robotics and Automation on Earth and in Space** - leveraging Australia's expertise in robotics technology and systems for remote operation and exploration in space
- **Access to Space -** leverage international space missions and commercial launch activities from Australian territory to support industry growth.

Figure 7 Alignment of respondents with National Civil Space Priority Areas



As indicated in Figure 7, there is significant activity in all priority areas, with at least 20 respondent organisations participating in each of the seven Australian Space Agency National Civil Space Priority Areas. Of interest in this segmentation is that Leapfrog R&D has the highest number of respondents, with 46 organisations indicating activities in this area. This is consistent with 47 organisations indicating R&D activities in the Space Segments question referred to above and flows from the fact that this study was commissioned by a research organisation with many of its members responding to the survey.

It is interesting to note that in previous studies, the space communications sector has consistently been shown as the area of the industry with the most participants (by both number of organisations and staff) and yet it does not have the largest number of respondents in this study, notwithstanding the fact that space communications is one of the key SmartSat research programs.

Also of note is the large number of organisations indicating activities in Space Situational Awareness and Debris Monitoring, showing this is a growing area and likely one for ongoing research. The relatively low number of respondents in Robotics and Automation is also surprising, given the high level of activity and research in this area

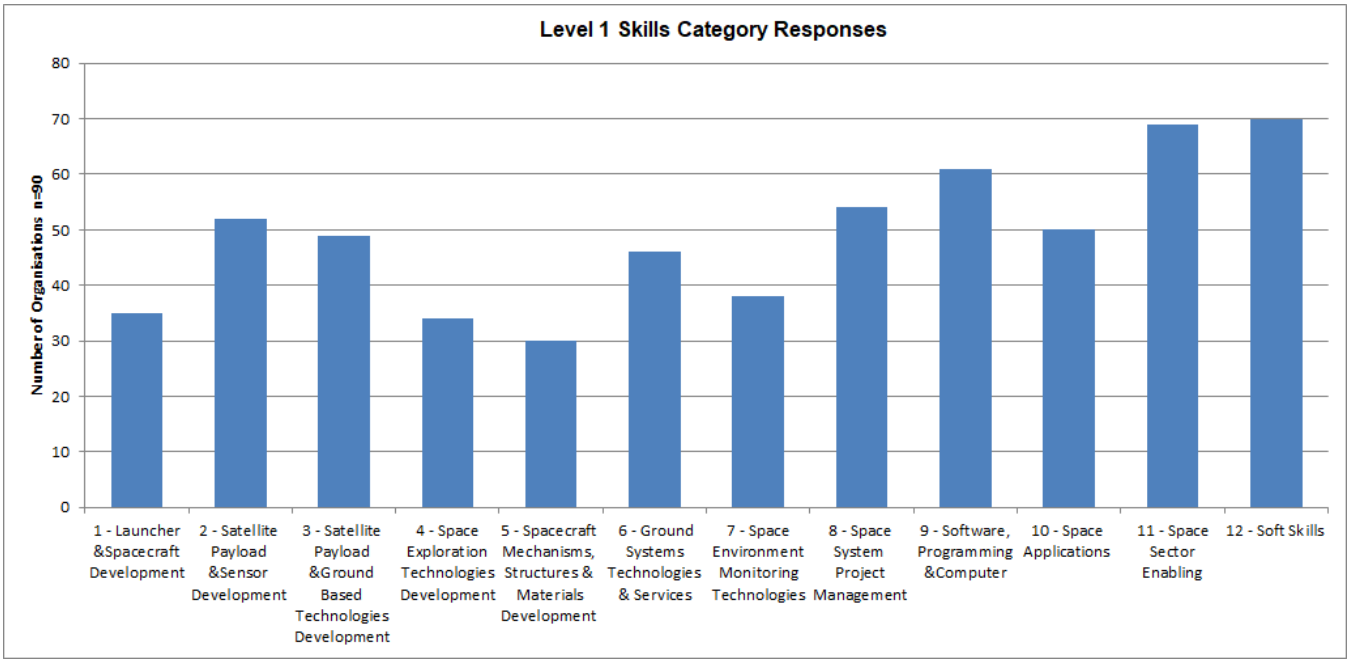
and its key role in future space activities.

6.7 Breakdown of respondent organisations by Tier One skills categories

6.7.1 Overall responses by skills category

Participants were asked to indicate each of the Tier One Skills categories in the ASST that apply to their current and/or future activities. The number of respondents in each of these Tier One categories is indicated in Figure 8.

Figure 8 Number of respondents with skills needs by Tier One skills category



The highest number of respondents (77%-78%) indicated that soft skills and space sector enabling skills (specialised business, finance, regulatory, legal skills) are critical for their activities. At one level, this is a natural result since these skills are increasingly required for any modern business. However, it is unusual to see these recognised so clearly in an industry where technical skills tend to dominate. This suggests a level of business sophistication in Australia's space industry where the importance of soft skills and business enabling skills is recognised.

The next highest skills category is software, programming, and computer skills with 67% of respondents. This is not surprising, as software and computer skills are critical to modern high-tech industries such as space. Also of significance is space system project management, where 58% of respondents indicated its importance. This is also critical for space projects but is historically often overlooked in surveys such as this. Again, this indicates a degree of critical holistic awareness by the industry of many of the critical factors for success in the space industry.

Also of note is that space applications does not have the highest number of respondents (since it has the highest number of organisations and staff in the Australian space sector), while satellite payload and sensor development and satellite payload and ground-based technologies rank on par with it. It is likely that this is due to the fact that many organisations involved in R&D responded to this survey and that these satellite areas are one of the SmartSat research programs.

6.7.2 Skills category breakdown by sector and size

Tables 8, 9, and 10 below indicate the number of respondent organisations for each skills category, where an organisation nominated one or more of the below subcategories for that Skills Category: a current skill, a current skills shortage, a future skill need, or that it is a training organisation for this skill. The tables show the aggregated responses by sector and organisation size in terms of staff numbers and revenue.

The total column in the tables shows that multiple respondents indicated current skills and/or current or future skills shortages and/or training capabilities in each of the Tier One skills categories. This indicates that multiple organisations in Australia are actively involved in all Tier One categories. Analysis shows that 31% of respondents have capabilities or needs in Category Five - Spacecraft Mechanisms, Structures, and Materials Development Skills, which is the lowest number of respondents for any of the Tier One skills categories.

Conversely, 78% of respondents indicated capabilities or needs in Category 12 - Soft Skills and 77% indicated capabilities or needs in Category 11 – Space Sector Enabling Skills, which represent the highest responses for any of the 12 Tier One categories.

Table 8 shows that most organisations with these skills, capabilities, or needs are in the private and university sectors, which is as expected.

Table 8 Number of organisations with space-related skill categories by industry sector

Sector	Private	University	Govt	NFP	Total
Category 1 - Launcher and Spacecraft Development	21	10	3	2	36
Category 2 - Satellite Payload and Sensor Development	29	16	4	3	52
Category 3 - Satellite Payload and Ground-based Technologies Development	30	13	4	2	49
Category 4 - Space Exploration Technologies Development	17	11	3	3	34
Category 5 - Spacecraft Mechanisms, Structures, and Materials Development s	18	9	3	1	31
Category 6 - Ground Systems Technologies and Services	30	10	6	1	47
Category 7 - Space Environment Monitoring Technologies	23	13	2	1	39
Category 8 - Space System Project Management	35	10	6	4	55
Category 9 - Software, Programming and Computer	37	15	7	3	62
Category 10 - Space Applications	27	13	7	3	50
Category 11 - Space Sector Enabling Skills	39	18	7	5	69
Category 12 - Soft Skills	42	17	6	5	70
TOTAL	**56**	**21**	**8**	**5**	**90**

Table 9 indicates the distribution of respondents' capabilities or needs across the 12 Tier One Categories, by size of the organisation based on number of employees, while Table 10 indicates this data by size of the organisation based on revenue.

Table 9 Number of organisations with space-related skill categories by organisation size – no. of employees

Size of organisation by employees	Large >200	Medium 20-200	Small 5-19	Micro 0-4	Total
Category 1 - Launcher and Spacecraft Development	14	8	7	7	36
Category 2 - Satellite Payload and Sensor Development	22	12	10	8	52
Category 3 - Satellite Payload and Ground-based Technologies Development	19	13	8	9	49
Category 4 - Space Exploration Technologies Development	15	6	6	7	34
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	12	9	4	6	31
Category 6 - Ground Systems Technologies and Services	20	13	9	5	47
Category 7 - Space Environment Monitoring Technologies	17	10	6	6	39
Category 8 - Space System Project Management	20	15	9	11	55
Category 9 - Software, Programming and Computer Skills	27	12	12	11	62
Category 10 - Space Applications	25	12	7	6	50
Category 11 - Space Sector Enabling Skills	30	16	11	12	69
Category 12 - Soft Skills	27	15	12	16	70
TOTAL	**35**	**18**	**18**	**19**	**90**

Table 10 number of organisations with space-related skill categories by organisation size - revenue

Size of organisation by revenue	Large >$250m	Medium $10m-$250m	Small <$10m	Revenue not indicated	Total
Category 1 - Launcher and Spacecraft Development	9	6	19	2	36
Category 2 - Satellite Payload and Sensor Development	16	11	23	2	52
Category 3 - Satellite Payload and Ground-based Technologies Development	12	13	22	2	49
Category 4 - Space Exploration Technologies Development	11	5	16	2	34
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	9	6	14	2	31
Category 6 - Ground Systems Technologies and Services	13	13	19	2	47
Category 7 - Space Environment Monitoring Technologies	11	9	17	2	39
Category 8 - Space System Project Management	12	14	27	2	55
Category 9 - Software, Programming and Computer Skills	18	12	30	2	62
Category 10 - Space Applications	17	11	20	2	50
Category 11 - Space Sector Enabling Skills	20	15	32	2	69
Category 12 - Soft Skills	17	15	36	2	70
TOTAL	**23**	**19**	**46**	**2**	**90**

Analysis of Table 9 indicates that large organisations (based on number of employees) have indicated the largest skills capabilities or needs in every Tier One skills category. Table 10 indicates that small organisations (based on revenue) represent the largest skills capabilities or needs in every Tier One skills category. This seems to imply that most organisations with Tier One skills category capabilities or needs tend to be larger organisations by staff numbers with smaller revenues. These findings seem typical of the profile of space industry organisations in Australia and hence indicate that the findings of this study are representative of this aspect of the industry.

A more detailed analysis of the responses down to the Tier Three skills will be covered in the below sections.

7.0 Strengths and limitations of the study

This skills gap analysis was a multi-faceted and complex study based on a detailed and complex survey instrument. Like most studies of this magnitude, there are significant strengths in the data collected but also some limitations that might constrain the inferences that can be derived from the data. This section highlights the strengths of the data as well as its limitations, to allow for a clear understanding of the results, conclusions and recommendations included in this report.

7.1 Strengths of the study

This study yielded a robust dataset that is valid for SmartSat to use as a first step towards understanding the Australian space sectors current and future skill requirements.

The key strengths of the study include the below:

- The 90 useable responses produced a large dataset that provides robustness to the findings of the study.
- A high number of companies and universities responded and the relative responses by sector largely match the profile of Australia's space industry in terms of organisation location, size, sector and space-related activities, as found in three previous related studies by APAC for the Australian Government in 2010[15], 2011[16] and 2015-16[17]. The data and findings can therefore be considered as a representative sample of the whole Australian space sector.
- There was a good response from SmartSat members, with 41 members (36%) completing the survey. This included 11 (61%) of SmartSat core members.
- A good cross-section of the Australian space sector, in the form of 49 non-SmartSat members, also completed the survey. These numbers ensure the survey data is representative of the broader Australian space sector beyond the interests of SmartSat.
- The survey produced a robust data set that was able to meet the objectives of this study, which, as noted, were to:

    1. Identify the gap in key skills in the Australian space industry
    2. Identify the gap in skills most relevant to SmartSat
    3. Identify gaps in soft skills, technical skills, and technology specific skills relevant to the higher education, professional development, and vocational education sectors, and
    4. Identify the areas of industry where these skills exist and relevant training providers with capability to provide training to fill gaps.

- The study has yielded data that provides SmartSat with a quick reference guide to current and future skills needs and potential areas of high intensity in an accessible format, to enable additional exploration and quantification.
- The data and sensitivity analysis described below provides information that can inform an Australian space industry training needs analysis.
- The study has mapped space-related skills to SmartSat priorities across its three major research programs and three key enabling themes.

[15] A Review of Current Australian Space Activities, Asia Pacific Aerospace Consultants. 2010.
[16] A Review of Current Australian Space Activities, Asia Pacific Aerospace Consultants, 2011.
[17] A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services, Asia Pacific Aerospace Consultants, 2015-16.

7.2. Limitations of the study

It is important to note some limitations inherent in the data collected via the survey. In constructing the survey, it was important to achieve a balance in the depth of data sought versus the number and detail of questions that respondents could be expected to answer.

During survey development, the SmartSat team and the WSU and APAC team noted the considerable number of space industry surveys that had been conducted in 2020 and recognised that survey fatigue was a real possibility among potential respondents, which might adversely impact the level and detail of responses. Hence, there were some practical limits on the number and depth of the questions that could be asked, and the degree of detail required from respondents to maximise the final number of respondents. Given these practical constraints, not all desired quantitative data could be collected through one survey.

Noting the above, some of the inherent limitations of the study are:

- The data does not provide the quantum of skills needs. It identifies needs but not the size of the need. The data was collected by respondent organisation based on the organisation's assessment of whether it had identified current or future needs. The survey did not request quantification of the number of current staff, current skills, skills shortages, or future skills needs. Hence the data only identifies the number of respondent organisations expressing that they have a shortage or a future requirement of any particular skill(s). It does not express the size of that shortage or future requirement.

- The data does not capture a complete picture of potential training providers. Whilst, as noted, the data collected is a representative sample of the Australian space industry, it does not provide a complete picture of all the providers of education and training for the relevant skills. For example:

    - many universities did not respond.
    - no vocational training organisations such as TAFE responded, and
    - many training and education providers for the more ubiquitous skills, such as project management and soft skills, operate outside of the space industry, and hence were unlikely to be aware of this study.

- The data does not capture a complete picture of the range of skills the training providers can cover. Of the 46 training and education providers which responded to the survey, 20 did not indicate any specific skills in the ASST for which they could provide services. This means that the number of training providers in the taxonomy of skills is likely to be understated. This will require further in-depth study into the key target areas to obtain more detailed information about the specifics of training and education providers.

- The data appears to under-represent aspects of skill shortages and future needs. It appears that up to 46% (41) respondents may not have realised that they should select *all* relevant options to indicate current skills employment, current skills shortages, future skills needs and whether they provide training for each skill. This provided some inconsistencies in the data between the 49 (54%) who made multiple responses and those who only gave single responses. The result is that some categories required manipulation of the data to achieve a proper basis for comparison and suggests therefore that the data is not sufficiently robust for absolute quantitative analysis. The below section describes in detail how this was compensated for by conducting a sensitivity analysis in lieu of a quantitative gap analysis.

8.0 Unexpected results and impact on analysis

8.1 Unexpected character of data collected

This study was initiated to identify current shortages and/or gaps and future needs in job skills for the Australian space sector, with an implicit expectation that there would be a moderate number of gaps that could be identified via a detailed survey.

The study was structured to obtain current space-related skills in Australian organisations, current shortages, and future needs.

This process led to two unexpected findings about the nation's space-related skills:

1. Australian organisations collectively already have almost all 319 Tier Three skills in the ASST. All but two of those 319 Tier Three skills currently exist within the 90 organisations that responded to this survey. The only skills identified as not currently existing collectively within those 90 organisations are:

    - 5.1.8 pyrotechnic technologies (note that the WSU and APAC team is aware of an organisation that has these skills but did not respond to the survey)

    - 5.1.9 flexible capture technologies.

The data suggests that Australian organisations in essence collectively already have the complete range of space-related skills covered in the ASST.

2. There are current skills shortages in all but nine of the 319 Tier Three skills in the ASST. The survey respondents identified current skills shortages across 310 (97%) of the 319 Tier Three skills. The only Tier Three skills not listed as being subject to a current shortage were:

1.6.5	other fluid dynamics technologies
3.4.1	laser technologies
3.4.3	photonics
3.4.4	optical communication technologies (incl. intersatellite links)
3.4.6	other optoelectronic technologies
4.1.6	manipulation
4.1.7	human robot interaction
4.1.8	robotics integration
4.1.9	other robotic systems.

These unexpected results indicate that essentially all the ASST skills exist in Australian organisations, yet shortages exist for nearly every skill. This suggests an industry poised for growth. It also implies there may be imbalances between skills capability and shortages across the Australian space industry and that there may be a need for training to address shortages.

The unexpected finding that (virtually) all skills exist, and yet there is a current shortage for those same skills, potentially created challenges for the WSU and APAC team to derive meaning from the data beyond these two broad findings. As a result, other analytical methods were explored and employed to derive further relevant information about the nature and detail of skills needs in line with the purposes of this study.

8.2 Sensitivity analysis vs quantitative analysis

The study yielded an exceptionally large data set, giving rise to complex considerations as to how to best analyse the data, driven in part by a few inherent limitations. The trade-off of limiting detail to encourage survey completion, which meant that quantitative data was not specifically requested, is that it constrains the ability to undertake quantitative analysis. The inconsistencies in some responses to the ASST and other sections of the survey also diminish the ability to conduct robust quantitative analysis. These limitations mean that the collected data is not suited to an accurate quantitative analysis.

Hence the below analysis of current skills shortages and future requirements is conducted through the lenses of sensitivity or relativity rather than absolute quantitative analysis. Quantifying the exact scope and number of people to cater for in training and education will require further in-depth study into the high priority areas identified through the sensitivity analysis described below.

8.3 Sensitivity analysis of current skills shortages

A sensitivity analysis was conducted to identify the areas most worthy of attention and emphasis in relation to a workforce planning and analysis for training and education needs. Two different modes of comparison were explored to identify the most significant area of skills shortage:

1. Comparing the number of organisations identifying a particular shortage against the number of organisations stating that they currently employ or require these skills. This in essence measured the skills shortfall against the current demand for that skill.

2. Comparing the number of organisations identifying a shortage against the number of training providers that stated that they provide training for that skill. This method highlights areas where there is a relative shortage of trainers compared to the number of organisations identifying a related skills shortage. This latter method will be fully addressed in Section 10 on training gaps.

8.3.1 Measuring skill shortages relative to current skills available

The nature of the data collected allows for two alternative ways to measure shortages relative to current demand for that skill:

1. Shortage to supply - Comparing the number of organisations identifying a current shortage to the number stating they currently already possess the relevant skill.

2. Shortage to demand - Comparing the number of organisations identifying a current shortage to the total number of organisations currently requiring that skill (i.e., they currently employ the skill and/or currently experience a skills shortage).

For the purposes of this analysis, the second mode of sensitivity analysis has been adopted to determine the proportion of organisations with unmet demand for current skill requirements.

To highlight areas of emphasis, a heat map was developed to indicate current shortages versus current demand. A simple set of ratios was developed to help emphasise the shortages that deserve most attention. Applying these ratios via a simple heat map overlaid onto the data set highlights the skills shortages of greatest concern.

For the purposes of this heat mapping, a ratio of 0.33 was applied as the first threshold for sensitivity and a ratio of 0.5 was used to indicate greatest concern. In practical terms, a ratio of 0.33 means that one in every three (33%) organisations requiring a particular skill is experiencing a shortage, while a ratio of 0.5 means the number

of organisations experiencing a skills shortage exceeds 50% of the number of organisations with a current demand for that skill.

8.3.2 Measuring skills shortages relative to available training providers

The second method of measuring shortages was to compare the number of organisations identifying a shortage of a particular skill against the number of organisations stating that they provide training for that skill. As for the comparison of shortage to demand, a heat map was developed to apply to the data set of current skills shortages versus current training providers. A simple set of ratios was developed to help emphasise the skills training needs that deserve most attention. Applying these ratios via a simple heat map overlaid onto the data set highlights the skills shortages which are most extreme compared to the number of trainers available. For the purposes of this heat mapping, a ratio of 5 was applied as the first threshold for sensitivity and a ratio of 10 was used to indicate greatest concern. In practical terms, a ratio of 5 means that there are five organisations with a shortage of a particular skill for every one organisation providing training in that skill, while a ratio of 10 means that there are ten organisations with a shortage of a particular skill for every one organisation providing training in that skill.

8.4 Sensitivity analysis of future skills requirements

Another surprising outcome of the study was that the survey responses anticipated future skills requirements for ***all*** (100%) of the 319 Tier Three skills identified in the ASST designed for the survey. In response to this broad finding, a sensitivity analysis was conducted to identify the areas most worthy of attention for future workforce planning and for analysis of training and education to build future capability. Two modes of comparison were developed to identify the most significant area of future skills requirements:

1. Comparing the number of organisations anticipating a future skills requirement against the number of organisations stating that they currently employ or require these skills. This measured future demand against current demand for that skill.

2. Comparing the number of organisations anticipating a future requirement against the number of training providers that stated they provide training for that skill. This method highlights areas where there is a relative shortage of trainers compared to the number of organisations identifying a shortage of that skill. This latter method will be fully addressed in Section 10. 8.4.1 - Measuring future requirements relative to available skills.

The nature of the data collected allows for two ways to measure shortages relative to current demand for that skill:

1. Future demand to current supply - comparing the number of organisations anticipating a future requirement to the number stating they now have the relevant skill.

2. Future demand to current demand - comparing the number of organisations anticipating a future requirement to the total number of organisations currently requiring that skill (i.e. they currently employ that skill and/or currently experience a skills shortage).

For the purposes of this analysis, the first mode of sensitivity analysis has been adopted, to determine the degree to which the current skill base must be increased to meet future demand.

To highlight areas of emphasis, a heat map was developed to indicate anticipated future skills requirements versus current supply. A simple set of ratios was developed to help emphasise the shortages that deserve most attention. Applying these ratios via a simple heat map overlaid onto the data set highlights the future requirements of greatest concern. A ratio of 1.20 was applied as the first threshold for sensitivity and a ratio of 2.0 was used to

indicate greatest concern. In practical terms, a ratio of 1.20 means that there are 20% more organisations requiring the skill for the future compared to the number of organisations who currently have the skill, while a ratio of 2 means that the number of organisations anticipating a future need for the skill is double the number of organisations that currently employ the skill.

8.4.2 Measuring skills shortage relative to available training providers

The second method of assessing future skills development was to compare the number of organisations anticipating a future requirement for a skill against the number of organisations stating that they provide training for that skill. As for the assessment of current skills shortages described above, a heat map was developed to apply to the data set of future skills requirements versus current training providers.

A simple set of ratios was developed to help emphasise the skills training gaps that deserve most attention. Applying these ratios via a simple heat map overlaid onto the data set highlights the future skills requirements which are most extreme compared to the number of trainers available. A ratio of 5 was applied as the first threshold for sensitivity and a ratio of 10 was used to indicate greatest concern. A ratio of 5 means there are five organisations with an anticipated future demand for a particular skill for every one organisation providing training in that skill, while a ratio of 10 means there are ten organisations with anticipated future demand for a skill for every one organisation providing relevant training.

These sensitivity analyses are used to highlight the highest intensity current skills shortages and future needs as well as identifying potential gaps in training and future training needs as described in the below sections.

9.0 Findings on current skills, shortages, and future requirements

This section presents the basic data obtained about current skills, shortages, future requirements, and number of training providers by each Tier Three skill as identified by the respondent organisations. This section also presents the basic data derived from the sensitivity analyses used to determine the highest intensity areas in terms of shortages, future requirements, and potential shortages of training providers.

Summary

The 90 respondent organisations indicated they collectively now have skills capability in 317 of the 319 Tier Three skills in the ASST. However, they also indicated there is a current shortage in 310 of these same 319 Tier Three skills and that there are future requirements in all the Tier Three skills.

To obtain more meaningful information from the data, the WSU and APAC team conducted various sensitivity analyses as described in Section 8 - unexpected data and impact on analysis, to identify the relative intensity of the needs for the various skills.

Table 11 shows the number of Tier Three skills within each Tier One Skills Category indicated as high or moderate intensity in terms of shortages, future requirements and potential shortages of training providers based on the sensitivity analysis. Further details on these Tier Three Skills, including which are high and moderate intensity, are shown in each Tier One Skills Category subsection within this section.

Table 11 High and moderate intensity sensitivity skills per Tier One skills category

Tier One skills categories	High intensity skills	Moderate intensity skills	Total Tier Three skills
1 - Launcher and Spacecraft Development	3	4	33
2 - Satellite Payload and Sensor Development	0	4	10
3 - Satellite Payload and Ground-Based Technologies Development skills	1	6	28
4 - Space Exploration Technologies Development	13	9	40
5 - Spacecraft Mechanisms, Structure, and Materials Development	15	16	34
6 - Ground Systems Technologies and Services	7	4	14
7 - Space Environment Monitoring Technologies	1	8	9
8 - Space System Project Management	2	11	14
9 - Software, Programming, and Computer skills	9	22	40
10 - Space Applications	3	12	21
11 - Space Sector Enabling Skills	7	17	31
12 - Soft Skills	0	2	45
TOTAL Tier Three Skills	**61**	**115**	**319**

An analysis of the implications and findings of this basic data and the gap analysis of skills and training providers is provided in Section 10.

Presentation of the basic data on current skills, skills shortages, future skills requirements and number of training providers

This section is structured around the 12 Tier One categories. Each subsection corresponding to a Tier One category contains a table showing each of the Tier Two skills groups and the survey results for each of the Tier Three skills and highlights of the findings. In each table, the first two columns contain the number and name of the Tier Three skill from the ASST. Columns 3 to 6 show the number of organisations indicating current skills, shortages, future requirements and the number of training and education providers for that Tier Three skill.

Presentation of the sensitivity analyses

Columns 7 and 8 depict the sensitivity analyses for current shortages for each Tier Three skill. Column 7 shows the sensitivity analysis ratio for organisations with current shortages. The ratio is expressed as current shortage to current total demand. Column 8 contains the sensitivity analysis ratio for organisations with current shortages to training and education providers that identified themselves in the survey for each Tier Three skill.

Columns 9 and 10 depict the sensitivity analyses for future requirements to current skills. Column 9 contains the sensitivity analysis ratio for organisations with future requirements. The ratio is expressed as organisations with future demand to organisations with current skills for each Tier Three skill. Column 10 contains the sensitivity analysis ratio for organisations with future requirements to training and education providers that identified themselves in the survey for each Tier Three skill.

Column 11 contains the number of SmartSat CRC research programs or enabling themes that utilise each Tier Three skill.

Colour coding has been used in **Columns 3, 7, 8, 9, and 10** to indicate levels of intensity as a heat map to show areas of heightened interest.

Heat map colour coding to highlight hot spots in the sensitivity analyses:

Column 3 current skills uses only a single level of colour coding of dark red to highlight the Tier Three skills where three or less survey respondent organisations currently have that skill.

Columns 7 – 10 all use a three-level colour coding scheme of no colour, light red and dark red to indicate increasing levels of intensity. The thresholds for change of intensity and the implications of these thresholds are different for three of the four columns. The specific thresholds for each column and their implications are described in Table 12.

Table 12 Heat map colour coding

Colour Code		
Colour	**Thresholds**	**Implications**
Current Skill Shortages		
Column 7	**Current Shortage to Demand**	
No Colour	0 - 0.33	<33% organisations have shortage
Light Red	0.33 - 0.5	33% - 50% organisations have shortage
Dark Red	Above 0.5	>50% organisations have shortage
Column 8	Current Shortage to Training Providers	
No Colour	0 - 5	< 5 organisations with shortage per training provider
Light Red	5 - 10	5 - 10 organisations with shortage per training provider
Dark Red	Above 10	>10 organisations with shortage per training provider
Future Skill Requirements		
Column 9	**Future Demand to Current Supply**	
No Colour	0 - 1.2	<20% more organisations with future need above organisations with current skill
Light Red	1.2 - 2	20% - 200% more organisations with future need than organisations with current skill
Dark Red	Above 2	>200% more organisations with future need than organisations with current skill
Column 10	**Future Demand to Training Providers**	
No Colour	0 - 5	< 5 organisations with future demand per training provider
Light Red	5 - 10	5 - 10 organisations with future demand per training provider
Dark Red	Above 10	>10 organisations with future demand per training provider

This section presents the basic results of the survey data and the sensitivity analyses, and it breaks down the results for each Tier One skills category. In the remainder of this section, high intensity skill shortages and requirements will be identified individually for each Tier One category, while the number of moderate intensity skill shortages and requirements will be summarised. However, it should be noted that the moderate intensity, individual skill shortages and requirements can still be identified in the table accompanying the description of each Tier One Category.

The implications of this data and the gap analysis of skills and training providers will be provided in later sections. A presentation of skills shortages and future skills requirements by Tier One Category follows in this section.

9.1 Category 1: Launcher and Spacecraft Development

Table 13 Skill shortages and future requirements for launcher and spacecraft development

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Launcher and Spacecraft Development Skills										
1.1	**Propulsion Systems**				6					**1**
1.1.1	Chemical Space Propulsion	8	3	6	1	0.30	3.00	0.75	6.00	**1**
1.1.2	Electric Space Propulsion	4	3	12	2	0.50	1.50	3.00	6.00	**1**
1.1.3	Aero Propulsion	4	2	7	3	0.33	0.67	1.75	2.33	**0**
1.1.4	Advanced Propulsion	3	6	8	3	0.75	2.00	2.67	2.67	**0**
1.1.5	Supporting Propulsion Technologies	9	3	5	4	0.25	0.75	0.56	1.25	**0**
1.1.6	Other Propulsion Systems	6	1	6	4	0.14	0.25	1.00	1.50	**1**
1.2	**Flight Computing and Avionics**				4					**1**
1.2.1	Avionics Component Technologies	10	3	7	3	0.25	1.00	0.70	2.33	**1**
1.2.2	Avionics Systems & Subsystems	13	4	10	4	0.25	1.00	0.77	2.50	**1**
1.2.3	Avionics Tools, Models & Analysis	11	3	8	4	0.25	0.75	0.73	2.00	**1**
1.2.4	Other Flight Computing & Avionics	11	3	7	3	0.25	1.00	0.64	2.33	**1**
1.3	**Guidance, Navigation & Control**				5					**1**
1.3.1	Guidance & Targeting Algorithms	8	4	8	2	0.40	2.00	1.00	4.00	**1**
1.3.2	Control Technologies	12	4	8	5	0.29	0.80	0.67	1.60	**1**
1.3.3	Navigation Technologies	13	4	6	1	0.29	4.00	0.46	6.00	**1**
1.3.4	Attitude Estimation Technologies	12	4	8	3	0.29	1.33	0.67	2.67	**1**
1.3.5	GNC Systems Engineering Technologies	9	4	10	1	0.33	4.00	1.11	10.00	**1**
1.3.6	Other Guidance, Navigation & Control Systems	10	2	8	4	0.18	0.50	0.80	2.00	**1**
1.4	**Space Systems Electrical Power**				5					**0**
1.4.1	Power Electronics	15	4	7	5	0.24	0.80	0.47	1.40	**0**
1.4.2	Power Generation Technologies	12	3	8	5	0.21	0.60	0.67	1.60	**0**
1.4.3	Energy Storage Technologies	11	4	8	4	0.29	1.00	0.73	2.00	**0**
1.4.4	Power Conditioning and Distribution	12	3	8	5	0.21	0.60	0.67	1.60	**0**
1.4.5	Other Space Systems Electrical Power	10	2	8	3	0.18	0.67	0.80	2.67	**0**
1.5	**Thermal Management Systems**				6					**0**
1.5.1	Heat Transport Technology	8	3	6	3	0.27	1.00	0.75	2.00	**0**
1.5.2	Cryogenics & Refrigeration Systems	7	3	4	2	0.30	1.50	0.57	2.00	**0**
1.5.3	Thermal Control Technology	12	4	8	3	0.25	1.33	0.67	2.67	**0**
1.5.4	Thermal Protection Technology	11	5	5	5	0.31	1.00	0.45	1.00	**0**
1.5.5	Heat Storage and Rejection Technology	8	3	7	3	0.27	1.00	0.88	2.33	**0**
1.5.6	Thermal Analysis Tools	12	6	5	5	0.33	1.20	0.42	1.00	**0**
1.5.7	Other Thermal Technologies	7	2	6	2	0.22	1.00	0.86	3.00	**0**
1.6	**Fluid Dynamics**				4					**0**
1.6.1	Fluid Dynamics Tools and Techniques	9	2	6	3	0.18	0.67	0.67	2.00	**0**
1.6.2	Ground Based Facilities	7	2	3	2	0.22	1.00	0.43	1.50	**0**
1.6.3	Sensors & Measurements Techniques for Fluid Dynamics	7	1	3	3	0.13	0.33	0.43	1.00	**0**
1.6.4	Flight Demonstrators and Flight Data Tools	10	3	2	3	0.25	1.00	0.20	0.67	**0**
1.6.5	Other Fluid Dynamics Technologies	8	0	4	3	0.00	0.00	0.50	1.33	**0**

As Table 13 reveals, there are now organisations with skills in every one of the 33 Tier Three areas within Tier One Skills Category One. The heat map indicates that 7 (21%) of these skills areas are of high (dark red shading) or moderate (lighter red shading) intensity for current shortages and/or anticipated future demand. The three (9%) skills in the high intensity area of the sensitivity analysis for this category are described in detail below.

Quantitative assessment

A basic quantitative assessment shows that almost all skills in Tier One Skills Category One currently exist in many organisations. Only one skill is identified from the sensitivity analysis of current skills.

- One skills area where there are three or less organisations with those skills that responded to the survey

- advanced propulsion

Current shortage sensitivity analysis

The sensitivity analysis of current shortages for Tier One Skills Category One indicates the below as high intensity areas for current shortages:

- One skills area based on the percentage of organisations experiencing high intensity current skills shortage relative to current skills demand:
  - advanced propulsion
  - Five additional skill areas indicate a moderate intensity shortage

- Skills areas based on the ratio of organisations with current skills shortage per training provider:
  - No high intensity skills areas
  - No moderate intensity skills areas
  - These findings indicate there are likely to be enough training providers to build capability to fill the current shortages for Tier One, Skills Category One.

Anticipated future demand sensitivity analysis - Tier One Category One

The sensitivity analysis for this category identifies the below as high intensity areas for future demand:

- Two areas based on the ratio of anticipated future demand relative to supply:
  - electric space propulsion
  - advanced propulsion
  - one additional skills area indicates moderate intensity future demand

- One skills area based on the ratio of organisations with anticipated future skills demand per training provider:
  - Guidance, Navigation and Control (GNC) systems engineering technologies
  - three additional areas indicate moderate intensity future training gap.

Current skills shortages and future demand relevant to SmartSat

- None of the high intensity current shortages identified above are in areas relevant to SmartSat activities

- Three of the moderate intensity current shortages identified above are in areas relevant to SmartSat (Research Program Two)

- Two of the high intensity future requirements (combined skills or training shortages) are in areas of relevance to SmartSat:
  - Electric Space Propulsion (Research Program Two)
  - GNC Systems Engineering Technologies (Research Program Two).

- One of the moderate intensity areas based on the ratio of organisations with anticipated future skills demand per training provider is of relevance to SmartSat.

9.2 Category 2: Satellite Payload and Sensor Development

Table 14 Skill Shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Satellite Payload and Sensor Development Skills					**10**					
2.1	**On-Board Data Subsystems**				**6**					**3**
2.1.1	Payload Data Processing	23	5	9	4	0.21	1.25	0.39	2.25	**3**
2.1.2	On-Board Data Management	21	5	12	5	0.23	1.00	0.57	2.40	**3**
2.1.3	Microelectronics for Digital and Analogue Applications (incl FPGA's)	21	9	10	6	0.38	1.50	0.48	1.67	**2**
2.1.4	Machine Learning and AI for On-Board Data Systems	17	5	16	5	0.25	1.00	0.94	3.20	**4**
2.1.5	Other On-Board Data Subsystems	14	3	7	2	0.19	1.50	0.50	3.50	**3**
2.2	**Sensors & Instruments**				**9**					**2**
2.2.1	Earth Observation Instruments & Sensors	23	9	15	6	0.32	1.50	0.65	2.50	**2**
2.2.2	Space Observatory Instruments & Sensors	12	3	9	5	0.23	0.60	0.75	1.80	**0**
2.2.3	In-Situ Instruments & Sensors	17	9	8	5	0.39	1.80	0.47	1.60	**1**
2.2.4	Instrument and sensor calibrations	15	9	8	5	0.41	1.80	0.53	1.60	**1**
2.2.5	Other Sensors & instruments	12	6	5	5	0.33	1.20	0.42	1.00	**0**

As Table 14 reveals, there are organisations with skills in every one of the 10 Tier Three areas within the above category. The heat map indicates that 4 (40%) of these areas are high intensity (dark red shading) or moderate intensity (lighter red) for current shortages and/or anticipated future demand.

Quantitative assessment

A basic quantitative assessment shows that all skills in Tier One Skills Category Two currently exist in many organisations. The current skills intensity analysis indicates:

- No skills areas in Tier One Skills Category Two where there are three or less organisations with those skills that responded to the survey.

Current skills shortage sensitivity analysis

The sensitivity analysis of current skills shortages for Tier One Skills Category Two indicates the below as high intensity areas for skills shortages.

- Skills based on the percentage of organisations experiencing high intensity current shortages relative to current demand:
  - no high intensity skills areas
  - four skills areas indicating moderate intensity shortages.

- Skills areas based on the ratio of organisations with current shortages per training provider:
  - no high intensity areas
  - no moderate intensity areas
  - these findings indicate there are likely to be enough training providers to build capability to fill the current shortages for Tier One Skills Category Two.

Anticipated future demand sensitivity analysis

The sensitivity analysis of anticipated future skills demand for Tier One Skill Category Two Satellite Payload and Sensor Development identifies the below as high intensity areas for future demand.

- Skills areas based on the ratio of anticipated future demand relative to supply:
  - no high intensity future skills areas
  - no moderate intensity future demand areas.

- Skills areas based on the ratio of organisations with anticipated future demand per training provider:
  - no high intensity areas
  - no moderate intensity areas
  - these findings indicate there are likely to be enough training providers to build capability to fill the future training gap for Tier One Skills Category Two.

Current shortages and future demand relevant to SmartSat

- No high intensity skills shortages identified above in areas relevant to SmartSat activities

- No high intensity future requirements in areas of relevance to SmartSat.

9.3 Category Three: Satellite Payload and Ground-Based Technologies Development

Table 15 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Satellite Payload and Ground Based Technologies Development Skills					**10**					
3.1	**RF Subsystems, Payloads and Technologies**				**8**					**2**
3.1.1	Telecommunications Subsystems	18	4	8	8	0.20	0.50	0.44	1.00	**2**
3.1.2	Radio Navigation Subsystems	10	3	6	5	0.23	0.60	0.60	1.20	**0**
3.1.3	TT&C and Payload Data Transmitter (PDT) Subsystems	15	2	8	5	0.12	0.40	0.53	1.60	**2**
3.1.4	RF Payloads	15	6	9	7	0.30	0.86	0.60	1.29	**2**
3.1.5	RF Technologies & Equipment	19	7	8	6	0.30	1.17	0.42	1.33	**1**
3.1.6	Waveform Development	10	2	10	5	0.17	0.40	1.00	2.00	**1**
3.1.7	Other RF Technologies	11	4	7	6	0.29	0.67	0.64	1.17	**1**
3.2	**Electromagnetic Technologies & Techniques**				**8**					**2**
3.2.1	Antennas	18	8	6	8	0.38	1.00	0.33	0.75	**2**
3.2.2	Wave Interaction and Propagation	14	6	6	7	0.38	0.86	0.43	0.86	**1**
3.2.3	Electromagnetic and Radio Frequency Compatibility and Electrostatic Discharge	14	9	8	5	0.53	1.80	0.57	1.60	**1**
3.2.4	Other Electromagnetic Technologies	13	6	7	4	0.40	1.50	0.54	1.75	**1**
3.3	**Optics**				**5**					**2**
3.3.1	Optical Subsystem Engineering	10	3	8	4	0.25	0.75	0.80	2.00	**2**
3.3.2	Optical Components Technology and Materials	8	1	8	5	0.11	0.20	1.00	1.60	**2**
3.3.3	Optical Equipment and Instrument Technology	7	1	8	4	0.13	0.25	1.14	2.00	**2**
3.3.4	Other Optics Technologies	8	1	7	5	0.11	0.20	0.88	1.40	**2**
3.4	**Optoelectronics**				**5**					**2**
3.4.1	Laser Technologies	6	0	7	4	0.00	0.00	1.17	1.75	**2**
3.4.2	Detector Technologies	8	2	7	4	0.22	0.50	0.88	1.75	**2**
3.4.3	Photonics	8	0	6	4	0.00	0.00	0.75	1.50	**2**
3.4.4	Optical Communication Technologies (incl. Intersatellite Links)	6	0	9	3	0.00	0.00	1.50	3.00	**2**
3.4.5	Quantum Technologies	4	1	10	3	0.20	0.33	2.50	3.33	**2**
3.4.6	Other Optoelectronic Technologies	4	0	6	3	0.00	0.00	1.50	2.00	**2**
3.5	**Position, Navigation & Timing Technologies**				**5**					**0**
3.5.1	Radio Navigation Subsystems - Space	10	4	6	4	0.31	1.00	0.60	1.50	**0**
3.5.2	Radio Navigation Subsystems - Ground	15	5	6	4	0.28	1.25	0.40	1.50	**0**
3.5.3	Position, Navigation & Timing Networks	17	5	4	5	0.28	1.00	0.24	0.80	**0**
3.5.4	Other Position, Navigation & Timing Technologies	13	4	5	5	0.25	0.80	0.38	1.00	**0**
3.6	**Internet of Things Technologies**				**0**					**2**
3.6.1	Internet of Things services using satellites	10	6	10	Training provider left off survey options in error	0.40	Training provider left off survey options in error	1.00		**2**
3.6.2	Internet of Things ground based sensors and sensor networks using satellites	13	6	12		0.35		0.92		**2**
3.6.3	Other Internet of Things Technologies	11	5	9		0.33		0.82		**2**

As Table 15 shows, there are organisations with skills in every one of the 28 Tier Three skills areas in the above category. Data analysis revealed there was a problem with the training provider question for the Tier Three skills under Tier Two IoT Technologies and as a result, no training provider data was collected for these three Tier Three skills. Hence no analysis can be done on the training provider categories for Tier Two IoT Technologies.
The related training provider categories are shaded dark red (columns 6, 8, 10), but it is known that such providers do exist. Given the data discrepancy, these categories have been shaded to indicate that they are not the normal high intensity items. They have not been included in the sensitivity analysis but are addressed with the caveat that further information is needed to confirm whether they are in fact high intensity areas. The heat map indicates that 10 (4%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current shortages and/or anticipated future demand.

Quantitative assessment

A basic quantitative assessment shows that all skills in this category currently exist in many organisations. The current skills intensity analysis indicates:

- There are no skills areas in Tier One of Category Three with three or less respondent organisations with those skills.

Current skills shortage sensitivity analysis

This analysis indicates the below as high intensity areas for current shortages.

- Skills areas based on the percentage of organisations experiencing high intensity current shortage relative to current demand:
  - no high intensity skills areas
  - seven areas indicating a moderate intensity shortage.

- Skills areas based on the ratio of organisations with current shortage per training provider:
  - no high intensity areas
  - three areas within Internet of Things (IoT) Technologies which cannot be analysed against training providers and hence warrant further investigation - IoT services using satellites; IoT ground-based sensors and sensor networks using satellites, and other IoT technologies
  - no moderate priority skills areas.

Anticipated future demand sensitivity analysis

This analysis for Tier One Skills Category Three identifies the below as high intensity areas for future demand.

- One skills area based on the ratio of anticipated future demand relative to supply:
  - quantum technologies
  - two additional areas indicating moderate intensity future demand.

- Skills areas based on the ratio of organisations with anticipated future demand per training provider:
  - No high intensity future demand areas
  - No moderate intensity future demand areas
  - The Tier Three skills in IoT technologies cannot be assessed per training provider due to the lack of data on training providers and thus warrants further investigation.
  - With the possible exception of the IoT Technologies, which as noted above cannot be assessed, these findings indicate there are likely to be enough training providers to build capability to fill the future skills training gap for Tier One Skills Category Three.

Current Shortages and future demand relevant to SmartSat:

- no high intensity current shortages identified above in areas relevant SmartSat.

- seven moderate intensity areas of current shortages identified above that are in areas relevant to SmartSat

- one of the high intensity future requirements is in an area of relevance to SmartSat:
  - quantum technologies (Research Programs 1 and 2)

- two moderate intensity areas of future requirements identified above in areas relevant to SmartSat

- the training provider situation in the IoT category is of relevance to SmartSat and should be investigated

further.

9.4 Category Four: Space Exploration Technologies Development

Table 16 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Space Exploration Technologies Development Skills					**8**					
4.1	**Robotic Systems**				**7**					**0**
4.1.1	Robotic Applications and Concepts	13	2	10	5	0.14	0.40	0.77	2.00	0
4.1.2	Robotics Systems and Subsystems	10	1	9	5	0.09	0.20	0.90	1.80	0
4.1.3	Robotics Components and Technologies	10	1	7	5	0.09	0.20	0.70	1.40	0
4.1.4	Sensing & Perception	9	2	8	5	0.18	0.40	0.89	1.60	0
4.1.5	Mobility	6	1	6	3	0.17	0.33	1.00	2.00	0
4.1.6	Manipulation	7	0	7	3	0.00	0.00	1.00	2.33	0
4.1.7	Human Robot Interaction	9	0	6	5	0.00	0.00	0.67	1.20	0
4.1.8	Robotics Integration	7	0	7	4	0.00	0.00	1.00	1.75	0
4.1.9	Other Robotic Systems	6	0	7	3	0.00	0.00	1.17	2.33	0
4.2	**Autonomous Systems**				**5**					**1**
4.2.1	Autonomous Systems and Subsystems	11	5	10	4	0.36	1.25	0.91	2.50	1
4.2.2	Autonomous Components and Technologies	8	3	9	4	0.30	0.75	1.13	2.25	1
4.2.3	Autonomous Rendezvous & Docking	3	4	8	2	0.67	2.00	2.67	4.00	0
4.2.4	Situational & Self Awareness	8	2	8	4	0.22	0.50	1.00	2.00	1
4.2.5	Reasoning & Acting	6	3	7	3	0.38	1.00	1.17	2.33	1
4.2.6	Collaboration & Interaction	5	2	7	3	0.33	0.67	1.40	2.33	1
4.2.7	Engineering & Integrity	7	2	9	3	0.25	0.67	1.29	3.00	1
4.2.8	Other Autonomous Systems	6	2	8	2	0.29	1.00	1.33	4.00	1
4.3	**Planetary Body Exploration**				**1**					**1**
4.3.1	Mission Infrastructure, Sustainability & Supportability	2	4	11	1	0.67	4.00	5.50	11.00	0
4.3.2	Mission Operations and Safety	4	4	11	1	0.57	4.00	2.75	11.00	1
4.3.3	Other Exploration Destination Systems	2	3	10	1	0.60	3.00	5.00	10.00	0
4.4	**Entry, Descent & Landing**				**1**					**0**
4.4.1	Aeroassist & Atmospheric Entry	4	5	8	1	0.56	5.00	2.00	8.00	0
4.4.2	Descent	5	5	6	1	0.50	5.00	1.20	6.00	0
4.4.3	Landing	3	5	7	1	0.63	5.00	2.33	7.00	0
4.4.4	Vehicle Systems	6	3	9	1	0.38	3.00	1.50	9.00	0
4.4.5	Other Entry, Descent & Landing Systems	3	4	8	1	0.57	4.00	2.67	8.00	0
4.5	**In-Situ Resource Utilisation**				**3**					**0**
4.5.1	Resource Characterisation Technologies	7	1	7	3	0.13	0.33	1.00	2.33	0
4.5.2	In-Situ Instruments & Sensors	6	3	6	3	0.38	1.00	1.00	2.00	0
4.5.3	Resource Extraction Technologies	7	2	6	3	0.25	0.67	0.86	2.00	0
4.5.4	Resource Processing Technologies	6	2	5	3	0.25	0.67	0.83	1.67	0
4.5.5	Other In-Situ Resource Utilisation Technologies	6	2	6	3	0.25	0.67	1.00	2.00	0
4.6	**Human Health, Life Support & Habitation Systems**				**5**					**0**
4.6.1	Environmental Control, Life Support Systems & Habitation Systems	4	5	9	1	0.71	5.00	2.25	9.00	0
4.6.2	Extravehicular Activity Systems	1	3	6	0	1.00	Nil TP	6.00	Nil TP	0
4.6.3	Human Health & Performance	7	2	6	4	0.25	0.50	0.86	1.50	0
4.6.4	Environmental Monitoring, Safety & Emergency Response	4	4	6	0	0.67	Nil TP	1.50	Nil TP	0
4.6.5	Radiation	5	2	5	2	0.33	1.00	1.00	2.50	0
4.6.6	Human Systems Integration	6	2	6	3	0.29	0.67	1.00	2.00	0
4.6.7	Instrumentation in Support of Life Sciences	4	3	7	1	0.60	3.00	1.75	7.00	0
4.6.8	Instrumentation in Support of Physical Sciences	4	3	6	1	0.60	3.00	1.50	6.00	0
4.6.9	Applied Life Science Technology	3	2	6	1	0.50	2.00	2.00	6.00	0
4.6.10	Other Human Health & Life Support Systems	5	1	4	2	0.17	0.50	0.80	2.00	0

As Table 16 reveals, there are organisations with skills in every one of the 40 Tier Three areas within Tier One Category Skills Category Four. The heat map indicates that 22 (55%) of these areas are high intensity (dark red shading) or moderate intensity (lighter red) for current shortages and/or anticipated future demand. The 13 skills (32%) in the high intensity area of this sensitivity analysis are described in detail below.

Quantitative assessment

A basic quantitative assessment shows that most of the skills in Tier One Category Four currently exist in many organisations. The current skills intensity analysis indicates:

- Seven skills areas with three or less respondent organisations with those skills:
  - autonomous rendezvous and docking
  - mission infrastructure, sustainability, and supportability
  - other exploration destination systems
  - landing
  - other entry, descent, and landing systems
  - extravehicular activity systems
  - applied life science technology.

Current skills shortage sensitivity analysis

This analysis for Tier One Skills Category Four indicates the below as high intensity areas for current shortages.

- Twelve skills areas based on the percentage of organisations experiencing current shortages relative to demand:
  - autonomous rendezvous and docking
  - mission infrastructure, sustainability, and supportability
  - mission operations and safety
  - other exploration destination systems
  - aeroassist and atmospheric entry
  - landing
  - other entry, descent, and landing systems
  - environmental control, life support systems and habitation systems
  - extravehicular activity systems
  - environmental monitoring, safety, and emergency response
  - instrumentation in support of life sciences
  - instrumentation in support of physical sciences
  - plus, eight additional skill areas indicating a moderate intensity shortage.

- Two skills areas based on the ratio of organisations with current shortages per training provider:
  - extravehicular activity systems
  - environmental monitoring, safety and emergency response
  - there are four additional skills areas indicating a moderate intensity skills shortage.

- There are two areas where no provider indicated training capability:
  - extravehicular activity systems
  - environmental monitoring, safety and emergency response

These findings indicate there may be insufficient training providers in some areas to build capability to fill current shortages for Skills Category Four; however there is a need for additional training providers in some.

Anticipated future demand sensitivity analysis

Sensitivity analysis of anticipated future demand for Tier One Skills Category Four identifies the below as high intensity areas for future demand:

- Ten skills areas based on the ratio of anticipated future skills demand relative to supply:
    - autonomous rendezvous and docking
    - mission infrastructure, sustainability, and supportability
    - mission operations and safety
    - other exploration destination systems
    - aeroassist and atmospheric entry
    - landing
    - other entry, descent, and landing systems
    - environmental control, life support systems and habitation systems
    - extravehicular activity systems
    - applied life science technology
    - plus, eight additional skill areas indicating moderate intensity future skills demand.

- Five skills areas based on the ratio of organisations with anticipated future skills demand per training provider:
    - mission infrastructure, sustainability, and supportability
    - mission operations and safety
    - other exploration destination systems
    - extravehicular activity systems
    - environmental monitoring, safety, and emergency response
    - plus, nine additional skill areas indicating a moderate intensity future skills training gap.

Current skills shortages and future demand relevant to SmartSat

- There is one high intensity current skills shortage identified above in an area relevant to SmartSat.
    - Mission Operations and Safety (Enabling Theme Three)

There are three moderate intensity areas of current skills shortages identified above in areas relevant to SmartSat.

9.5 Category Five: Spacecraft Mechanisms Structures and Materials Development

Table 17 skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Spacecraft Mechanisms Structures & Materials Development Skills					**4**					
5.1	**Mechanisms**				**2**					**1**
5.1.1	Mechanism Core Technologies	7	5	3	1	0.50	5.00	0.43	3.00	**0**
5.1.2	Non-Explosive Release Technologies	5	4	4	0	0.50	Nil TP	0.80	Nil TP	**0**
5.1.3	Exploration Tool Technologies	4	2	4	1	0.33	2.00	1.00	4.00	**0**
5.1.4	Control Electronics Technologies	6	3	4	0	0.38	Nil TP	0.67	Nil TP	**1**
5.1.5	MEMS Technologies	4	3	3	0	0.50	Nil TP	0.75	Nil TP	**0**
5.1.6	Tribology Technologies	1	2	4	0	0.67	Nil TP	4.00	Nil TP	**0**
5.1.7	Mechanism Engineering	9	5	4	1	0.38	5.00	0.44	4.00	**0**
5.1.8	Pyrotechnic Technologies	0	5	5	0	1.00	Nil TP	Nil Current	Nil TP	**0**
5.1.9	Flexible Capture Technologies	0	4	3	0	1.00	Nil TP	Nil Current	Nil TP	**0**
5.1.10	Other Mechanisms	3	7	6	0	1.00	Nil TP	2.00	Nil TP	**0**
5.2	**Structures**				**3**					**0**
5.2.1	Structural Design and Verification Methods and Tools	15	3	7	3	0.18	1.00	0.47	2.33	**0**
5.2.2	High Stability and High Precision Spacecraft Structures	10	4	5	2	0.33	2.00	0.50	2.50	**0**
5.2.3	Inflatable and Deployable Structures	6	3	3	1	0.33	3.00	0.50	3.00	**0**
5.2.4	Hot Structures	4	2	1	1	0.33	2.00	0.25	1.00	**0**
5.2.5	Active/Adaptive Structures	4	3	3	1	0.50	3.00	0.75	3.00	**0**
5.2.6	Damage Tolerance and Health Monitoring	4	2	4	1	0.33	2.00	1.00	4.00	**0**
5.2.7	Launchers, Reentry Vehicles, Planetary Vehicles	4	5	6	0	0.63	Nil TP	1.50	Nil TP	**0**
5.2.8	Crew Habitation, Safe Haven and EVA Suits	1	4	4	0	0.80	Nil TP	4.00	Nil TP	**0**
5.2.9	Meteoroid and Debris Shield Design and Analysis	2	6	5	0	0.75	Nil TP	2.50	Nil TP	**0**
5.2.10	Advanced Structural Concepts and Materials	7	5	4	1	0.56	5.00	0.57	4.00	**0**
5.2.11	Other Structures	3	1	2	1	0.25	1.00	0.67	2.00	**0**
5.3	**Materials and Manufacturing Processes**				**2**					**2**
5.3.1	Novel Materials and Materials Technology	9	6	5	1	0.46	6.00	0.56	5.00	**0**
5.3.2	Materials Processes	9	3	3	1	0.30	3.00	0.33	3.00	**0**
5.3.3	Cleanliness and Sterilisation	6	5	4	1	0.56	5.00	0.67	4.00	**0**
5.3.4	Ground & Space Environmental Effects on Materials and Processes	9	4	3	1	0.33	4.00	0.33	3.00	**0**
5.3.5	Modelling of Materials Behaviour and Properties	7	4	4	1	0.44	4.00	0.57	4.00	**1**
5.3.6	Non-Destructive Inspection	6	3	5	1	0.33	3.00	0.83	5.00	**0**
5.3.7	Material and Process Obsolescence	5	1	3	1	0.17	1.00	0.60	3.00	**0**
5.3.8	Materials for Electronic Assembly	7	4	5	1	0.44	4.00	0.71	5.00	**2**
5.3.9	Advanced Manufacturing Technologies	8	6	10	2	0.55	3.00	1.25	5.00	**0**
5.3.10	Reliability and Reusability Aspects of Materials	6	1	3	1	0.14	1.00	0.50	3.00	**0**
5.3.11	Other Materials & Manufacturing	5	1	4	2	0.20	0.50	0.80	2.00	**0**
5.4	**Electrical, Electronic and Electro-mechanical (EEE) Components and Quality**				**0**					**2**
5.4.1	Methods and Processes for Product Assurance of EEE Components	2	4	7	0	0.44	Nil TP	1.40	Nil TP	**2**
5.4.2	EEE Component Technologies	48	5	8	0	0.63	Nil TP	2.00	Nil TP	**2**

As Table 17 reveals, there are organisations with skills in every one of the 34 Tier Three skills areas within Tier One Skills Category Five. The heat map indicates that 28 (82%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current skills shortages and/or anticipated future demand. The 12 skills (35%) of high intensity for this skills category are described in detail below.

Quantitative assessment

A basic quantitative assessment shows that most skills in Tier One Skills Category Five now exist in many organisations. The current skills intensity analysis indicates:

- Seven skills areas where there are three or fewer respondent organisations with those skills
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - advanced structural concepts and materials
  - other structures.

- Two skills areas where no organisation indicated current skills:
  - pyrotechnic technologies
  - flexible capture technologies.

- It is known there are organisations in Australia with capability in pyrotechnic technologies that did not respond to the survey. However, these findings indicate some areas of potential current skills deficits for this category.

Current skills shortage sensitivity analysis

The sensitivity analysis of current skills shortages for this category indicates the below skills as high intensity areas for current shortages.

- Ten skills areas based on the percentage of organisations experiencing current skills shortage relative to current skills demand:
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - launchers, re-entry vehicles, planetary vehicles
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - advanced structural concepts and materials
  - cleanliness and sterilisation
  - Electrical and Electronic Engineering (EEE) component technologies
  - plus 18 additional skills areas indicating moderate intensity skills shortages.

- Twelve skills areas based on the ratio of organisations with current shortages per training provider:
  - non-explosive release technologies
  - control electronics technologies
  - Micro Electro-Mechanical Systems (MEMS) technologies
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - launchers, re-entry vehicles, planetary vehicles
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - methods and processes for product assurance of EEE components
  - EEE component technologies

  - plus, five additional skill areas indicating moderate intensity skills shortages.

- There are twelve areas where no provider indicated training capability:
  - non-explosive release technologies
  - control electronics technologies
  - MEMS technologies
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - launchers, re-entry vehicles, planetary vehicles
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - methods and processes for product assurance of EEE components
  - EEE component technologies
  - these findings indicate there may be a shortage of training providers which could impact the ability to build capability to fill current shortages for Tier One Skills Category Five.

Anticipated future demand sensitivity analysis

Sensitivity analysis of anticipated future skills demand for this category identifies the below skills as high intensity areas for future demand:

- Seven skills areas based on the ratio of anticipated future skills demand relative to skills supply:
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - EEE component technologies
  - plus, three additional skills areas indicating moderate intensity future demand.

- Twelve skills areas based on the ratio of organisations with anticipated future skills demand per training provider:
  - non-explosive release technologies
  - control electronics technologies
  - MEMS technologies
  - tribology technologies
  - pyrotechnic technologies
  - flexible capture technologies
  - other mechanisms
  - launchers, re-entry vehicles, planetary vehicles
  - crew habitation, safe haven and EVA suits
  - meteoroid and debris shield design and analysis
  - methods and processes for product assurance of EEE components
  - EEE component technologies
  - plus, four additional skills areas indicating moderate shortage.

Current skills shortages and future demand relevant to SmartSat

- There are three high intensity current skills shortages identified above (combined skills or training

shortages) in areas relevant to SmartSat:
    - control electronics technologies (Research Program One)
    - methods and processes for product assurance of EEE components (Research Programs 1 and 2)
    - EEE component technologies (Research Programs 1 and 2)
    - plus, two additional moderate intensity areas of relevance to SmartSat.

- Three of the high intensity future skills requirements (combined skills or training shortages) are in areas of relevance to SmartSat:
    - control electronics technologies (Research Program One)
    - methods and processes for product assurance of EEE components (Research Programs One and Two)
    - EEE component technologies (Research Programs One and Two)
    - one additional moderate intensity area of relevance to SmartSat.

9.6 Category Six: Ground Systems Technologies and Services

Table 18 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Ground Systems Technologies & Services Skills					**6**					
6.1	**Ground Station Systems and Networks**				**5**					**1**
6.1.1	Ground Station Systems	21	7	9	3	0.30	2.33	0.43	3.00	1
6.1.2	Ground Communication Networks	17	8	10	2	0.40	4.00	0.59	5.00	1
6.1.3	Ground Station Equipment	21	6	9	2	0.26	3.00	0.43	4.50	1
6.1.4	Ground Station Software	18	7	10	1	0.33	7.00	0.56	10.00	1
6.1.5	Other Ground Station Technology	14	5	5	2	0.31	2.50	0.36	2.50	1
6.2	**Mission Operations and Ground Data Systems**				**2**					**1**
6.2.1	Advanced System and Mission Operation Concepts	14	5	11	1	0.31	5.00	0.79	11.00	1
6.2.2	Mission Operations	15	9	16	1	0.47	9.00	1.07	16.00	1
6.2.3	Ground Data Systems	16	3	7	0	0.18	Nil TP	0.44	Nil TP	1
6.2.4	Other Mission Ops & Ground Data Technologies	10	2	7	0	0.18	Nil TP	0.70	Nil TP	1
6.3	**Ground, Test & Surface Systems**				**2**					**2**
6.3.1	Infrastructure Optimisation	10	2	10	0	0.17	Nil TP	1.00	Nil TP	1
6.3.2	Test & Qualification	19	7	13	2	0.32	3.50	0.68	6.50	2
6.3.3	Assembly, Integration & Launch	12	10	11	2	0.53	5.00	0.92	5.50	2
6.3.4	Mission Success Technologies	13	5	10	1	0.29	5.00	0.77	10.00	1
6.3.5	Other Ground, Test & Surface Systems	10	4	9	1	0.31	4.00	0.90	9.00	1

As Table 18 reveals, there are organisations with skills in every one of the 14 Tier Three skills areas within Tier One Skills Category Six. The heat map indicates that 11 (79%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current skills shortages and/or anticipated future demand. The seven skills (50%) in the high intensity area of the sensitivity analysis for this skills category are described in detail below.

Quantitative assessment

A basic quantitative assessment of highest intensity skills areas shows that most of the skills in this category exist now in many organisations. The current skills intensity analysis indicates:

- no skills areas in Tier One Skills Category Six where there are three or less respondent organisations.

Current skills shortage sensitivity analysis

The sensitivity analysis of current skills shortages for this category indicates the below as high intensity areas for current shortages:

- skills areas based on the percentage of organisations experiencing high intensity current shortages relative to current demand:
  - no high priority skills areas
  - four skills areas indicating a moderate intensity skills shortage.

- Three skills areas based on the ratio of organisations with current shortages per training provider:
  - ground data systems
  - other mission operations and ground data technologies
  - infrastructure optimisation.

- There are three areas where no training provider indicated capability:
    - ground data systems
    - other mission operations and ground data technologies
    - infrastructure optimisation
    - There are five additional skills areas indicating a moderate intensity skills shortage per training provider
    - These findings indicate there may be insufficient training providers in some areas to build capability to fill the current shortages for Skills Category Six.

Anticipated future demand sensitivity analysis

This analysis identifies the below as high intensity areas for future demand.

- Skills areas based on the ratio of anticipated future demand relative to supply:
    - no high intensity areas
    - no moderate intensity areas.

- Seven skills areas based on the ratio of organisations with anticipated future demand per training provider:
    - ground station software
    - advanced system and mission operation concepts
    - mission operations
    - ground data systems
    - other mission operations and ground data technologies
    - Infrastructure optimisation
    - Mission success technologies
    - four additional skills areas indicating a moderate future training gap
    - These findings indicate there may be insufficient training providers in some areas to build capability to fill future demand for Skills Category Six.

Current skills shortages and future demand relevant to SmartSat

- Three high intensity current skills shortages identified above (combined skills or training shortages) are in areas relevant to SmartSat:
    - ground data systems (Research Program One)
    - other mission operations and ground data technologies (Research Program One)
    - infrastructure optimisation (Research Program One)
    - There are two additional moderate intensity areas of relevance.

- Seven of the high priority future skills requirements (combined skills or training shortages) are relevant to SmartSat:
    - ground station software (Research Program One)
    - advanced system and mission operation concepts (Research Program One)
    - mission operations (Research Program One)
    - ground data systems (Research Program One)
    - other mission operations and ground data technologies (Research Program One)
    - infrastructure optimisation (Research Program One)
    - mission success technologies (Research Program One)
    - four additional moderate intensity areas.

9.7 Category Seven: Space Environment Monitoring Technologies

Table 19 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Space Environment Monitoring Technologies Skills					**8**					
7.1	**Space Systems Environments and Effects**				**6**					**0**
7.1.1	Space Environments	19	8	11	6	0.38	1.33	0.58	1.83	**0**
7.1.2	Environments Effects	13	7	9	4	0.44	1.75	0.69	2.25	**0**
7.1.3	Space Weather	11	8	9	4	0.53	2.00	0.82	2.25	**0**
7.1.4	Other Space Systems Environments & Effects	10	4	6	5	0.33	0.80	0.60	1.20	**0**
7.2	**Space Situational Awareness**				**6**					**1**
7.2.1	Ground and Space Based Debris Tracking	14	6	9	4	0.35	1.50	0.64	2.25	**0**
7.2.2	Modelling and Risk Analysis	10	4	8	3	0.33	1.33	0.80	2.67	**0**
7.2.3	Debris Mitigation	8	5	6	2	0.45	2.50	0.75	3.00	**1**
7.2.4	Debris Remediation and Protection	3	5	7	2	0.83	2.50	2.33	3.50	**1**
7.2.5	Other Space Situational Awareness	13	7	11	3	0.44	2.33	0.85	3.67	**0**

As Table 19 reveals, there are organisations with skills in every one of the nine Tier Three skills areas within Tier One Skills Category Seven. The heat map indicates that all (100%) of these areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current shortages and/or anticipated future demand. The one skill (11%) in the high intensity area of the sensitivity analysis for this category is described in detail below.

Quantitative assessment

A basic quantitative assessment of highest intensity skills areas shows that most skills in this category currently exist in many organisations. The current skills intensity analysis indicates:

- One skills area where there are three or fewer respondent organisations with those skills that responded to the survey
  - debris remediation and protection.

Current skills shortage sensitivity analysis

The sensitivity analysis of current skills shortages for Tier One Skills Category Seven indicates the below as high intensity areas for current shortages.

- One skills area based on the percentage of organisations experiencing current shortages relative to demand:
  - debris remediation and protection
  - eight additional skills areas indicating moderate intensity shortage.

- Skills areas based on the ratio of organisations with current shortages per training provider:
  - no high intensity areas
  - no moderate intensity areas
  - these findings suggest there may be sufficient training providers to build capability to fill current shortages for Skills Category Seven.

Anticipated future demand sensitivity analysis

This analysis identifies the below as high intensity areas for future demand.

- One skills area based on the ratio of anticipated future skills demand relative to skills supply:
  - debris remediation and protection
  - no additional skills areas indicating a moderate intensity future skills demand.

- Skills areas based on the ratio of organisations with anticipated future skills demand per training provider:
  - no high intensity skills areas
  - no moderate intensity skills areas
  - these findings suggest there may be enough training providers to build capability to fill the future skills training gap for Skills Category Seven.

Current skills shortages and future demand relevant to SmartSat

- One high intensity current skills shortage identified above is in an area relevant to SmartSat:
  - debris remediation and protection (Enabling Theme Three).

- One high intensity future skills requirement is in an area of relevance to SmartSat:
  - debris remediation and protection (Enabling Theme Three)

9.8 Category Eight: Space System Project Management

Table 20 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Space System Project Management Skills					**7**					
8.1	**Management of Space Projects**				**3**					**6**
8.1.1	Project Management of Space Projects	29	20	16	3	0.50	6.67	0.55	5.33	6
8.1.2	Risk Management of Space Projects	26	20	15	3	0.54	6.67	0.58	5.00	6
8.1.3	Systems Engineering Skills for Space Projects	29	19	13	3	0.50	6.33	0.45	4.33	6
8.2	**Systems Design & Verification**				**6**					**5**
8.2.1	Project Management for Space Projects	25	15	11	5	0.44	3.00	0.44	2.20	4
8.2.2	Mission and System Specification	28	16	11	5	0.46	3.20	0.39	2.20	4
8.2.3	Collaborative and Concurrent Engineering	22	12	14	5	0.43	2.40	0.64	2.80	3
8.2.4	System Analysis and Design	27	11	15	6	0.34	1.83	0.56	2.50	5
8.2.5	System Verification and Assembly, Integration and Test	22	13	17	5	0.46	2.60	0.77	3.40	4
8.2.6	Other Systems Design & Verification	14	3	7	4	0.18	0.75	0.50	1.75	4
8.3	**Quality, Dependability and Safety**				**3**					**5**
8.3.1	System Dependability and Safety	16	12	11	1	0.50	12.00	0.69	11.00	4
8.3.2	Software Quality	21	12	11	2	0.44	6.00	0.52	5.50	5
8.3.3	Product and Quality Assurance	17	12	13	1	0.46	12.00	0.76	13.00	5
8.3.4	Commercial Off-The-Shelf Components and Subsystems	23	6	10	2	0.24	3.00	0.43	5.00	3
8.3.5	Other Quality & Safety	13	2	8	1	0.14	2.00	0.62	8.00	4

As Table 20 reveals, there are organisations with skills in every one of the 14 Tier Three skills areas within the broader category of Tier One Skills Category Eight. The heat map indicates that all but one (93%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current skills shortages and/or anticipated future demand. The two skills (14%) in the high intensity area of the sensitivity analysis for this category are described in detail below.

Quantitative assessment

A basic quantitative assessment of highest intensity skills areas shows that most of the skills in this category exist now in many organisations. The current skills intensity analysis indicates:

- No skills areas where there are three or less respondent organisations with those skills.

Current skills shortage sensitivity analysis

This analysis indicates the below as high intensity areas for current shortages.

- Skills areas based on the percentage of organisations experiencing current shortages relative to current demand:
  - no high intensity skill areas
  - 11 skills areas indicating moderate intensity shortage.

- Skills areas based on the ratio of organisations with current shortages per training provider:
  - no high intensity areas
  - four moderate intensity areas
  - these findings suggest there may be enough training providers to build capability to fill current shortages for Skills Category Eight.

Anticipated future demand sensitivity analysis

The below skills were identified as high intensity areas for future demand.

- Skills areas based on the ratio of anticipated future demand relative to supply:
    - no high intensity areas
    - no moderate intensity areas.

- Two skills areas of high intensity based on the ratio of organisations with anticipated future demand per training provider:
    - system dependability and safety
    - product and quality assurance
    - plus, five additional skills areas indicating a moderate intensity future training gap
    - these findings suggest that additional training providers may be required in the Tier Two skills areas of quality, dependability, and safety, as well as project management.

Current skills shortages and future demand relevant to SmartSat

- No high intensity current shortages identified above in areas relevant to SmartSat.

- 11 moderate intensity areas of current shortages relevant to SmartSat.

- The two high intensity future skills requirements (combined skills or training shortages) are in areas of relevance to SmartSat:
    - system dependability and safety (Research Programs One, Two and Three; Enabling Theme Two)
    - product and Quality Assurance (Research Programs One, Two and Three; Enabling Themes One and Two)
    - five moderate intensity areas of future requirements relevant to SmartSat.

9.9 Category Nine: Software, Programming and Computer Skills

Table 21 Skills shortages and future requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Software, Programming & Computer Skills					**13**					
9.1	**Software used with Space Systems**				**6**					**4**
9.1.1	Software Technologies	31	10	10	6	0.29	1.67	0.32	1.67	4
9.1.2	Space Segment Software	16	15	13	3	0.60	5.00	0.81	4.33	2
9.1.3	Ground Segment Software	23	8	11	3	0.31	2.67	0.48	3.67	2
9.1.4	Ground Data Processing	23	7	11	4	0.27	1.75	0.48	2.75	2
9.1.5	Systems Development and Operations	21	10	8	3	0.37	3.33	0.38	2.67	1
9.2	**Remote sensing /Earth Observation Software**				**7**					**1**
9.2.1	Biophysical image processing fundamentals (measurements from images)	14	9	9	6	0.47	1.50	0.64	1.50	1
9.2.2	Passive and active image data correction	14	10	11	4	0.50	2.50	0.79	2.75	1
9.2.3	Passive and active image data processing	16	11	13	5	0.50	2.20	0.81	2.60	1
9.2.4	Passive and active image product and service validation	14	9	11	4	0.47	2.25	0.79	2.75	1
9.2.5	Biophysical image data spatial-temporal processing	15	10	9	6	0.50	1.67	0.60	1.50	1
9.3	**Software, Modelling, Simulation & Information Processing**				**8**					**5**
9.3.1	Software Development, Engineering & Integrity	31	15	9	5	0.41	3.00	0.29	1.80	5
9.3.2	Modelling	31	14	8	5	0.36	2.80	0.26	1.60	4
9.3.3	Simulation	32	13	9	7	0.35	1.86	0.28	1.29	4
9.3.4	Information Processing	27	11	8	5	0.33	2.20	0.30	1.60	4
9.3.5	Mission Architecture, Systems Analysis & Concept Development	18	11	11	2	0.42	5.50	0.61	5.50	4
9.3.6	Ground Computing	18	7	5	3	0.30	2.33	0.28	1.67	3
9.3.7	Other Software, Modelling, Simulation & Information Processing	19	7	4	4	0.30	1.75	0.21	1.00	4
9.4	**Flight Dynamics and GNSS**				**1**					**0**
9.4.1	Flight Dynamics (FD)	7	6	9	1	0.50	6.00	1.29	9.00	0
9.4.2	GNSS High-Precision Data Processing	6	8	8	0	0.62	Nil TP	1.33	Nil TP	0
9.5	**Artificial Intelligence & Machine Learning**				**9**					**4**
9.5.1	Artificial Intelligence Systems & Algorithms	25	12	16	8	0.39	1.50	0.64	2.00	4
9.5.2	Machine Learning Systems & Algorithms	27	13	16	9	0.41	1.44	0.59	1.78	4
9.5.3	Deep Learning Systems, Algorithms & Techniques	23	12	14	8	0.41	1.50	0.61	1.75	3
9.5.4	Advanced Analytical Techniques	24	12	14	8	0.41	1.50	0.58	1.75	4
9.5.5	Data Analytics and Data Fusion	28	12	15	8	0.38	1.50	0.54	1.88	4
9.5.6	Data Visualisation Techniques	24	12	14	8	0.41	1.50	0.58	1.75	2
9.5.7	Digital Twin Techniques	20	13	14	6	0.48	2.17	0.70	2.33	4
9.5.8	Other AI & ML techniques	19	11	12	7	0.46	1.57	0.63	1.71	3
9.6	**Virtual Reality Technologies**				**5**					**1**
9.6.1	Data Visualisation Techniques	18	3	10	4	0.15	0.75	0.56	2.50	1
9.6.2	Visualisation of space environments & scenarios	10	4	10	3	0.29	1.33	1.00	3.33	0
9.6.3	Training techniques for space missions	5	6	10	2	0.67	3.00	2.00	5.00	0
9.6.4	Virtual Reality for Long Distance Spaceflight	3	4	7	1	0.57	4.00	2.33	7.00	0
9.6.5	Other Virtual Reality Technologies	9	2	4	4	0.20	0.50	0.44	1.00	0
9.7	**Quantum Computing Technologies**				**2**					**2**
9.7.1	Quantum Computing Techniques	3	2	11	2	0.40	1.00	3.67	5.50	2
9.7.2	Quantum Cryptography	2	2	9	2	0.50	1.00	4.50	4.50	2
9.7.3	Other Quantum Computing	2	2	6	2	0.50	1.00	3.00	3.00	2
9.8	**CyberSecurity & Resilience Technologies**				**3**					**4**
9.8.1	Cybersecurity for Space Systems	12	8	13	2	0.50	4.00	1.08	6.50	4
9.8.2	Resilience techniques for Space Systems	14	11	9	3	0.58	3.67	0.64	3.00	4
9.8.3	Cybersecurity for Ground Systems	15	8	11	2	0.42	4.00	0.73	5.50	4
9.8.4	Resilience techniques for Ground Systems	15	11	12	3	0.55	3.67	0.80	4.00	4
9.8.5	Other Security & Resilience Technologies	13	4	6	3	0.27	1.33	0.46	2.00	4

As Table 21 reveals, there are organisations with skills in every one of the 40 Tier Three skills areas within this broader category. The heat map indicates that 31 (78%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current shortages and/or anticipated future demand. The nine skills (23%) in the high intensity area of the sensitivity analysis are described in detail below.

Quantitative assessment

A basic quantitative assessment of highest intensity skills areas shows that most of the skills in this category now exist in many organisations. The current skills intensity analysis indicates:

- Four skills areas where there are three or less organisations with those skills that responded to the survey:
    - virtual reality for long distance spaceflight
    - quantum computing techniques
    - quantum cryptography
    - other quantum computing.

Current skills shortage sensitivity analysis

This analysis found the below skills as high intensity areas for current shortages.

- Six skills areas based on the percentage of organisations experiencing current shortage relative to current demand:
    - space segment software
    - GNSS high-precision data processing
    - training techniques for space missions
    - virtual reality for long distance spaceflight
    - resilience techniques for space systems
    - resilience techniques for ground systems
    - 25 additional skills areas indicating a moderate intensity skills shortage.

- One skills area based on the ratio of organisations with current skills shortage per training provider:
    - Global Navigation Satellite System (GNSS) high-precision data processing
    - one area where no training provider indicated training capability - GNSS high-precision data processing
    - three additional moderate intensity skills areas
    - These findings suggest there may be insufficient training providers in some areas to build capability to fill the current shortages for Category Nine Skills.

Anticipated future demand sensitivity analysis

The sensitivity analysis of anticipated future skills demand for Tier One Category Nine Skills identifies the below as high intensity areas for future demand.

- Five skills areas based on the ratio of anticipated future skills demand relative to skills supply:
    - training techniques for space missions
    - virtual reality for long distance spaceflight
    - quantum computing techniques
    - quantum cryptography
    - other quantum computing
    - two additional skills areas indicating moderate intensity future skills demand.

- One skills area based on the ratio of organisations with anticipated future demand per training provider:
    - GNSS high-precision data processing
    - seven additional skills areas indicating moderate intensity future skills training gaps
    - these findings indicate there may be insufficient training providers in some areas to build capability to fill the future demand for this category.

Current skills shortages and future demand relevant to SmartSat

- Three high intensity current skills shortages identified above (combined skills or training shortages) in

areas relevant to SmartSat:
    - Space segment software (Research Programs One and Two)
    - resilience techniques for space systems (Research Programs One, Two and Three and Enabling Theme Two)
    - resilience techniques for ground systems (Research Programs One, Two and Three and Enabling Theme Two)
    - there are 24 additional moderate intensity areas of current skills shortages relevant to SmartSat.

- Three of the high intensity future requirements (combined skills or training shortages) are in areas of relevance to SmartSat:
    - quantum computing techniques (Research Programs One and Two)
    - quantum cryptography (Research Programs One and Two)
    - Other quantum computing (Research Programs One and Two)
    - Three additional moderate intensity areas of current skills shortages are relevant to SmartSat

9.10 Category 10: Space Applications Skills

Table 22 Skills shortages and future skills requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Space Applications Skills					**10**					
10.1	**Satellite Communications Services & Applications**				**3**					**2**
10.1.1	Satellite broadcast & communications products and services	7	3	7	3	0.38	1.00	1.00	2.33	**2**
10.1.2	Satellite Broadband Internet Products & Services (e.g. satellite internet systems)	5	3	5	1	0.50	3.00	1.00	5.00	**2**
10.1.3	Direct to home television products and services	3	2	2	1	0.40	2.00	0.67	2.00	**0**
10.1.4	Mobile Satellite Communications	7	4	6	1	0.44	4.00	0.86	6.00	**1**
10.1.5	Other Satellite Communications	6	2	7	2	0.29	1.00	1.17	3.50	**1**
10.2	**Earth Observation Services & Applications**				**7**					**2**
10.2.1	Earth observation data products and services for use in other areas of the economy	17	6	13	6	0.32	1.00	0.76	2.17	**1**
10.2.2	Earth Obs Data collection/storage/processing/validation/distribution/commodification	16	5	11	5	0.28	1.00	0.69	2.20	**2**
10.2.3	Geo-spatial and earth (planetary) observation data integration & analysis	16	6	12	5	0.32	1.20	0.75	2.40	**2**
10.2.4	IT & software development for earth observation data manipulation	17	7	7	5	0.37	1.40	0.41	1.40	**2**
10.2.5	Development of algorithms for Earth observation applications	16	8	11	6	0.40	1.33	0.69	1.83	**2**
10.2.6	Calibration (of sensors) and validation (of algorithms, products)	11	7	10	5	0.47	1.40	0.91	2.00	**1**
10.2.7	Functional Publications Derived from space-based data (Atlases, maps)	10	5	7	3	0.38	1.67	0.70	2.33	**0**
10.2.8	Other Earth Observation Services & Applications	9	2	5	4	0.20	0.50	0.56	1.25	**1**
10.3	**Global Positioning, Navigation and Timing Services & Applications**				**2**					**0**
10.3.1	Global positioning, navigation and timing products and services	9	8	9	2	0.50	4.00	1.00	4.50	**0**
10.3.2	Satellite navigation service providers, GNSS Services	6	7	6	1	0.58	7.00	1.00	6.00	**0**
10.3.3	Provision/exploitation of sat based location data	7	8	6	1	0.57	8.00	0.86	6.00	**0**
10.3.4	GIS data integration & analysis	11	6	7	1	0.38	6.00	0.64	7.00	**0**
10.3.5	IT & software for satnav data manipulation	7	6	5	1	0.50	6.00	0.71	5.00	**0**
10.3.6	Development of PNT networks	11	6	5	2	0.38	3.00	0.45	2.50	**0**
10.3.7	Other PNT Services & Applications	10	6	4	2	0.40	3.00	0.40	2.00	**0**
10.4	**Other Space Applications**				**1**					**0**
10.4.1	Please specify ()	7	1	4	1	0.13	1.00	0.57	4.00	**0**
	- - Microgravity Research Services									
	- Analysis of human-object interactions in space habitats									

Table 22 show there are organisations with skills in every one of the 21 Tier Three skills areas within this broader category. The heat map indicates that 15 (71%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current skills shortages and/or anticipated future demand. The two skills (10%) in the high intensity area of the sensitivity analysis are described in detail below.

Quantitative Assessment

A basic quantitative assessment of highest priority skills areas shows that most of the skills in Tier One Skills Category One currently exist in many organisations. The current skills intensity analysis indicates:

- One area where there are three or less organisations with those skills that responded to the survey:
  - Direct-to-home television products and services
  - Note that it is known that there are many organisations in Australia that possess this particular skill; hence this is probably an indication that not many satellite communications companies responded to this survey.

Current skills shortage sensitivity analysis

This indicates the below as high intensity areas for current shortages.

- Two skills areas based on the percentage of organisations experiencing current shortages relative to current skills demand:
  - satellite navigation service providers, GNSS services
  - provision/exploitation of sat-based location data

  - 13 additional skills areas indicating a moderate intensity skills shortage.

- Skills areas based on the ratio of organisations with current shortages per training provider:
  - no high intensity skills areas
  - four moderate intensity skills areas
  - There are likely to be sufficient providers to build capability to fill the current shortages for Skills Category One.

Anticipated future demand sensitivity analysis

The below were identified as high intensity areas for future demand.

- Skills areas based on the ratio of anticipated future demand relative to supply:
  - no high intensity areas
  - no moderate intensity areas.

- Skills areas based on the ratio of organisations with anticipated future demand per training provider:
  - no high intensity areas
  - six skills areas indicating a moderate intensity future skills training gap.

Current skills shortages and future demand relevant to SmartSat

- None of the high intensity skills shortages identified above are in areas relevant to SmartSat.

- Six relevant additional moderate intensity areas of current shortages.

- No high intensity future skills requirements

- Two additional moderate intensity areas of future skills requirements.

9.11 Category 11: Space Sector Enabling Skills

Table 23 Skills shortages and future skills requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills Current Supply	Number or Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider (Col G/I)	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider (Col H/I)	Number of CRC Research Program or Enabling Themes Utilising Skill
Space Sector Enabling Skills					**15**					
11.1	**Regulation and essential service delivery**				**5**					**1**
11.1.1	Establishing or enforcing Space regulation and legislation	17	10	11	3	0.48	3.33	0.65	3.67	1
11.1.2	Space related policy making	17	13	10	3	0.59	4.33	0.59	3.33	1
11.1.3	Facilitation of domestic and international connections between actors in the global space economy	24	12	12	5	0.43	2.40	0.50	2.40	1
11.2	**Space Education and Outreach**				**13**					**6**
11.2.1	Designing/developing education, training or skills development programs in space-related disciplines	22	7	13	11	0.27	0.64	0.59	1.18	6
11.2.2	Delivering education, training or development programs in space-related disciplines	27	8	13	12	0.25	0.67	0.48	1.08	6
11.2.3	Developing or delivering outreach or STEM education programs to schools and communities	21	6	14	10	0.24	0.60	0.67	1.40	6
11.2.4	Specialised communication, media and outreach skills for space and space science	15	8	13	6	0.38	1.33	0.87	2.17	0
11.3	**Space Related R&D and Engineering**				**6**					**5**
11.3.1	R&D related to non-commercial or pre-commercial activities	30	6	8	5	0.19	1.20	0.27	1.60	5
11.3.2	Planetary science, astronomy, astrophysics, advanced materials for space, atmospheric science, and astrobiology	13	5	8	4	0.33	1.25	0.62	2.00	0
11.3.3	Space medicine	6	2	6	2	0.25	1.00	1.00	3.00	0
11.3.4	Design of spacecraft, satellites and payloads or components thereof	28	11	9	4	0.37	2.75	0.32	2.25	4
11.3.5	Testing of spacecraft, satellites and payloads or components thereof	24	10	8	4	0.37	2.50	0.33	2.00	4
11.3.6	Design of ground segment equipment, hardware and components	17	7	5	4	0.32	1.75	0.29	1.25	3
11.3.7	Testing of ground segment equipment, hardware and components	17	8	6	4	0.36	2.00	0.35	1.50	3
11.3.8	Design of software necessary for space applications	19	8	9	4	0.35	2.00	0.47	2.25	5
11.3.9	Testing of software necessary for space applications	19	9	9	4	0.39	2.25	0.47	2.25	5
11.4	**Specialised Support Services**				**7**					**6**
11.4.1	Launch and satellite insurance (including brokerage)	5	10	5	2	0.71	5.00	1.00	2.50	0
11.4.2	Specialised space-related legal and/or contract management skills	11	10	8	3	0.59	3.33	0.73	2.67	5
11.4.3	Specialised space-related corporate governance skills	13	6	4	3	0.33	2.00	0.31	1.33	1
11.4.4	Specialised space-related risk management, audit and assurance skills	12	12	8	2	0.60	6.00	0.67	4.00	1
11.4.5	Specialised space-related economic analysis and review skills	9	9	8	1	0.53	9.00	0.89	8.00	1
11.4.6	Specialised space-related financial skills	9	8	7	1	0.53	8.00	0.78	7.00	0
11.4.7	Specialised space-related business development skills	20	10	11	2	0.40	5.00	0.55	5.50	0
11.4.8	Specialised space-related sales and marketing skills	14	6	8	0	0.32	Nil TP	0.57	Nil TP	0
11.4.9	Specialised space-related media management skills including social media	13	6	8	1	0.33	6.00	0.62	8.00	1
11.4.10	Specialised space-related business incubation skills	15	4	6	2	0.22	2.00	0.40	3.00	0
11.4.11	Specialised space-related market research services	6	7	4	0	0.58	Nil TP	0.67	Nil TP	0
11.4.12	Specialised space-related consultancy services	15	10	11	4	0.48	2.50	0.73	2.75	0
11.4.13	Specialised health services for astronaut health or space specific medical services	4	5	6	3	0.71	1.67	1.50	2.00	0
11.4.14	Specialised co-ordination skills to enable space sector actors throughout the value chain	12	6	5	2	0.40	3.00	0.42	2.50	0
11.4.15	Specialised space-related skills in working with, responding to and engaging with Government	18	7	7	1	0.33	7.00	0.39	7.00	6

As Table 23 reveals, there are organisations with skills in every one of the 31 Tier Three skills areas within this broader category. The heat map indicates that 24 (77%) of these skills areas are of high intensity (dark red shading) or moderate intensity (lighter red) for current skills shortages and/or anticipated future demand. The seven skills (23%) in the high intensity area of the sensitivity analysis for this category are described in detail below.

Quantitative assessment

A basic quantitative assessment of highest priority skills areas shows that all of the skills in this category now exist in many organisations. The current skills intensity analysis indicates:

- No skills area where there are three or less respondent organisations with those skills

Current skills shortage sensitivity analysis

The sensitivity analysis of current skills shortages for this category indicates the below skills as high intensity areas for current shortages.

- Six skills areas based on the percentage of organisations experiencing current shortages relative to current demand:
  - space related policy making
  - launch and satellite insurance (including brokerage)

  - specialised space-related legal and/or contract management skills
  - specialised space-related risk management, audit, and assurance skills
  - specialised space-related market research services
  - specialised health services for astronaut health or space specific medical services
  - 17 additional skills areas indicating a moderate intensity skills shortage.

- Two skills areas based on the ratio of organisations with current shortages per training provider:
  - specialised space-related sales and marketing skills
  - specialised space-related market research services
  - two skills areas where no training provider indicated training capability: specialised space-related sales and marketing skills; specialised space-related market research services
  - Seven moderate intensity skill areas
  - These findings suggest that there might be insufficient training providers in some areas to build capability to fill current shortages.

Anticipated future demand sensitivity analysis

The sensitivity analysis of anticipated future skills demand for this category identifies the below skills as high intensity areas for future demand:

- Skills areas based on the ratio of anticipated future demand relative to supply:
  - no high priority areas
  - one skills area indicating moderate intensity future skills demand.

- Skills areas based on the ratio of organisations with anticipated future demand per training provider:
  - specialised space-related sales and marketing skills
  - specialised space-related market research services
  - two skills areas where no training provider indicated training capability: specialised space-related sales and marketing skill; specialised space-related market research services
  - five additional skills areas indicating a moderate future skills training gap.

Current skills shortages and future demand relevant to SmartSat

- There are three high intensity current skills shortages identified above (combined skills or training shortages) of relevance.
  - space related policy making (Enabling Theme Three)
  - specialised space-related legal and/or contract management skills (Research Programs One, Two and Three and Enabling Themes One and Two)
  - specialised space-related risk management, audit and assurance skills (Enabling Theme Three)
  - 11 additional moderate intensity areas of current skills shortages relevant to SmartSat.

- There are no high intensity future skills requirements in areas of relevance to SmartSat:
  - Three additional moderate intensity areas of future skills requirements relevant to SmartSat.

9.12 Category 12: Soft skills

Table 24 Skills shortages and future skills requirements

Tier 2 Skills Group	Tier 3 Skill	Quantitative Data				Organisations with Current Skill Shortages		Future Skill Requirments to Current Skills		Relevance to CRC
		Number of Organisations That Currently Employ Skills - Current Supply	Number of Organisations with Current Skill Shortage	Number of Organisations with Future Skill Requirement Anticipated	Number of Organisations that are Training/ Education Providers	Current Skill Requirements: Skill Shortage (Shortage: Current Demand)	Skills Shortage per Training Provider	Adjusted Current Skills: Future Skills (Future Demand: Current Supply)	Organisations with Future Demand per Training Provider	Number of CRC Research Program or Enabling Themes Utilising Skill
Soft Skills – personal abilities to improve human performance and interaction					**18**					
12.1	**Communication Skills**				**16**					**6**
12.1.1	Verbal communication	58	9	14	13	0.15	0.69	0.24	1.08	6
12.1.2	Nonverbal communication	50	9	11	11	0.17	0.82	0.22	1.00	6
12.1.3	Active listening	50	12	12	10	0.22	1.20	0.24	1.20	6
12.1.4	Business writing	48	12	11	8	0.23	1.50	0.23	1.38	2
12.1.5	Technical writing	51	12	12	9	0.21	1.33	0.24	1.33	6
12.1.6	Public speaking/presentations	55	11	14	15	0.19	0.73	0.25	0.93	6
12.2	**Interpersonal skills**				**14**					**6**
12.2.1	Teamwork - operating effectively in a team environment	56	10	15	14	0.17	0.71	0.27	1.07	6
12.2.2	Collaboration - with others across different teams and contexts	55	13	15	14	0.22	0.93	0.27	1.07	6
12.2.3	Effective relationship building	48	12	12	10	0.22	1.20	0.25	1.20	6
12.2.4	Effective conflict management	45	14	14	9	0.26	1.56	0.31	1.56	6
12.2.5	Eliciting and including diverse views and thinking styles	47	14	12	11	0.26	1.27	0.26	1.09	6
12.2.6	Respecting and valuing differences due to disability, age, gender, religion, culture	47	11	13	10	0.22	1.10	0.28	1.30	6
12.3	**Leadership**				**14**					**6**
12.3.1	Inspiring others with the vision and direction	53	11	12	11	0.19	1.00	0.23	1.09	6
12.3.2	Taking people on the journey	52	11	12	11	0.19	1.00	0.23	1.09	6
12.3.3	Effective delegation	46	12	13	6	0.23	2.00	0.28	2.17	6
12.3.4	Holding people accountable	44	8	11	6	0.16	1.33	0.25	1.83	6
12.3.5	Managing poor performance	40	13	14	5	0.28	2.60	0.35	2.80	6
12.3.6	Developing others for STEM career paths	41	13	13	9	0.28	1.44	0.32	1.44	6
12.3.7	Integrity - walking the talk	46	10	10	6	0.20	1.67	0.22	1.67	6
12.3.8	Authenticity	47	8	9	7	0.16	1.14	0.19	1.29	6
12.4	**Self-management**				**10**					**6**
12.4.1	Emotional Intelligence	45	11	13	9	0.22	1.22	0.29	1.44	6
12.4.2	Workload management	45	13	15	8	0.25	1.63	0.33	1.88	6
12.4.3	Time-management	47	12	15	8	0.23	1.50	0.32	1.88	6
12.4.4	Resilience	48	8	11	7	0.16	1.14	0.23	1.57	6
12.4.5	Managing work/life balance	41	18	15	7	0.37	2.57	0.37	2.14	6
12.4.6	Setting effective boundaries	44	12	14	7	0.24	1.71	0.32	2.00	6
12.4.7	Managing personal and psychological wellbeing	43	12	16	7	0.24	1.71	0.37	2.29	6
12.5	**Influencing and persuasion skills**				**10**					**6**
12.5.1	Effective influencing of key stakeholders to achieve outcomes	45	17	16	10	0.31	1.70	0.36	1.60	6
12.5.2	Effective negotiation e.g. contracts, sales, pricing, project scoping	37	19	16	7	0.38	2.71	0.43	2.29	6
12.5.3	Effective influencing of subordinates to achieve outcomes	46	13	14	7	0.25	1.86	0.30	2.00	6
12.5.4	Effective influencing of peers to achieve outcomes	44	16	15	7	0.30	2.29	0.34	2.14	6
12.5.5	Effective influencing of senior management to achieve outcomes	44	14	14	7	0.27	2.00	0.32	2.00	6
12.6	**Creative thinking**				**11**					**6**
12.6.1	Innovation and creating new ideas	52	14	15	11	0.24	1.27	0.29	1.36	6
12.6.2	Thinking outside the square	52	16	16	10	0.27	1.60	0.31	1.60	6
12.7	**Adaptability**				**14**					**6**
12.7.1	Flexible thinking	48	10	12	10	0.19	1.00	0.25	1.20	6
12.7.2	Perspective Taking (ability to view from multiple perspectives)	47	11	12	10	0.21	1.10	0.26	1.20	6
12.7.3	Growth Mindset (thrives on learning, growth and stretching existing abilities)	48	10	13	11	0.19	0.91	0.27	1.18	6
12.7.4	Commitment to lifelong learning	48	9	13	12	0.17	0.75	0.27	1.08	6
12.7.5	Ability to embrace new technology	52	7	13	12	0.13	0.58	0.25	1.08	6
12.8	**Decision making & Problem-Solving**				**12**					**6**
12.8.1	Critical thinking	55	9	13	12	0.16	0.75	0.24	1.08	6
12.8.2	Abstract Reasoning	52	10	12	10	0.18	1.00	0.23	1.20	6
12.8.3	Ability to locate and use information	55	8	13	11	0.14	0.73	0.24	1.18	6
12.8.4	Ability to synthesise information	55	11	12	12	0.19	0.92	0.22	1.00	6
12.8.5	Effective and timely problem solving	53	7	14	11	0.13	0.64	0.26	1.27	6
12.8.6	Making timely and effective decisions	50	9	12	9	0.17	1.00	0.24	1.33	6

Table 24 shows there are many organisations with skills in every one of the 46 Tier Three skills areas within this category. The heat map indicates there are no areas that warrant high priority attention, but it does indicate two areas of moderate (lighter red) importance for current shortages – managing work/life balance and effective negotiation e.g. contracts, sales, pricing, and project scoping.

Soft skills – a different consideration

As described in Section 4.1, soft skills are considered to be of crucial importance to the space industry. There is pervasive and global evidence that STEM graduates are often not workplace-ready due to poorly developed soft

skills in self-management and the interpersonal dynamics of a workplace. Awareness of this importance to Australia's space industry was reflected in the survey results, where 70 (78%) of respondent organisations completed the sections relating to Tier One Skills Category Soft Skills, and made comments such as:

- 'All of these skills are required now and in the future. Soft skills are very important at our organisation.'
- 'Collaboration, the development of networks and alliances will be the determining factor of success in industry development and performance.'
- 'To achieve the industry's growth potential, a strong focus on effective collaboration and integrative diversity is required to promote innovation and scale. Collaboration requires effective negotiation, communication and strategic thinking skills, as well as the appropriate structural capital to support, capture and re-use/enhance knowledge.'
- 'Skill development that is focused on negotiation, collaboration (alliances, mergers, cross-functional teamwork, diversity etc.) will be the key to promoting constructive conflict and subsequent innovative solutions, while mitigating destructive conflict associated with identity and motivational differences.'

Soft skills development, education, and training

The data collected in the survey indicates the pervasive and ubiquitous requirement for soft skills for each person involved in the space industry (as indeed they are required for every industry). This is also a skills category that can draw on training and education providers beyond the space industry. There are a multitude of training providers beyond the scope of this survey, and hence there is no training provider gap. Consequently, soft skills will not be included in the more detailed skills gap analysis described in Sections 10 and 12.

The importance and challenge of developing soft skills in the space industry

The challenge in fostering soft skills in the more technical professions is that these professions tend to require a high task focus (as opposed to a people focus). This task focus is valued as a strength with respect to technical expertise. Developing a people focus to balance task focus is usually developed 'on the job' rather than during university training. It is crucial that organisations encourage and foster these skills in their employees and have leaders as role models.

The most important aspect of soft skills development is to foster a commitment to make them a priority and to frame their importance in achieving organisational and task outcomes. This requires a commitment to time and resources over and the industry of valuing these skills and developing leaders to inspire people and to effectively harness their talents to achieve synergistic outcomes, as eloquently described in the sample of comments above.

It also requires secondary and tertiary education providers to encourage students and individuals to develop these skills at an early stage, and we are seeing encouraging signs of recognition of by the growing trend for team-based assignments and workplace internships.

The survey findings indicate that the vast majority of respondents understand the importance of soft skills. The data shows that there is recognition of the need to develop soft skills now (as indicated by shortages) and to continue this into the future (indicated by anticipated future requirements) as a critical component to the growth of the Australian space industry.

10.0 Skills and training sensitivity analysis

One of the main objectives of this study was to identify the key skills needs in the Australian space industry. This section builds on the data presented thus far, particularly in Section 9 (findings on current skills, shortages, and future requirements), to analyse and present needs and training gaps.

The 90 respondent organisations indicated they now collectively have skills capability in 317 of the 319 Tier Three skills in the ASST. However, they also indicated a current skills shortage in 310 of these same 319 skills and that there are future skills requirements in all 319 of them.

The fact that the data indicates there are both current shortages and future requirements for (virtually) all Tier Three skills does help to identify the important skills needs on a broad and pervasive scale. However, such broad information is not particularly useful in planning strategies to address these needs. In particular, this data by itself gives little information about the intensity of the needs for the various skills in short supply.

To obtain more meaningful information, the WSU and APAC team conducted various sensitivity analyses as described in Section 8 (unexpected data and impact on analysis) to identify the relative intensity of needs for the various skills. These analyses were conducted on a range of measures that ultimately identified six potential indicators of skills shortage.

As a first step, six indicators were applied via a sensitivity analysis to the data on the 319 Tier Three skills in the taxonomy to assess intensity for the individual skills. These six indicators, and the results of the sensitivity analysis using each indicator, are as follows: redundancy

1. **Potential high intensity skills priorities:** The below three indicators provide insight into the intensity of current and future skills shortages in the workforce:

    a. **Skills currently employed by three or fewer organisations** – There are 10 Tier Three skills that were identified as existing in only three or fewer organisations. These skills are potentially at risk of becoming in short supply due to the low numbers of organisations with these skills. The rationale for including this indicator is the need to ensure sufficient capacity of skills remain available across the industry.

    b. **Skills currently in high demand due to shortages –**36 Tier Three skills were highlighted as potentially having critical shortages, based on 55% or more organisations that currently require the relevant skill, indicating they are experiencing a shortage. These 36 skills areas may be the highest priority for further investigation, to more comprehensively quantify the extent of shortages and potential demand for immediate skills development programs.

    c. **Skills with high future demand relative to the existing skills pool –**22 Tier Three skills were highlighted as future requirements by more than double the number of organisations than those that currently employ these skills. These areas are likely to be the subject of a skills shortage in the future and represent a high priority for further investigation to more comprehensively quantify the degree of potential shortage, for the purpose of developing new skills training programs to achieve industry growth targets.

2. **Potential high training gap priorities:** The below three indicators provide insight into the intensity of potential shortages of training providers:

    a. **Lack of training providers –**20 skills were identified as having no training providers amongst the respondent organisations. Further investigation is needed to determine if there is an urgent

requirement to source providers or develop training programs for these skills.

b. **Current shortage of skills training providers** – The study found only two Tier Three skills where the ratio of organisations with current shortages per training provider was ten or more. This suggests that, in general, where there are providers for current skills shortages, they appear to be in sufficient numbers to cater for demand. This assumption does require further investigation to quantify the number of people requiring skills training, rather than the number of organisations with shortages.

c. **Anticipated future requirements for more training providers –** In addition to the 20 Tier Three skills identified as having no training providers, there are 10 Tier Three skills where the ratio of organisations with anticipated future skills demand per training provider is ten or more. This suggests there is a strong requirement to develop more training capacity in these 10 skills areas to build the workforce of the future.

Section 9.0 'Findings on current skills, shortages and future requirements' presented the data gathered via the survey by Tier One Skills Category and identified the Tier Three skills in each Tier One Skills Category that registered high intensity on at least one of the sensitivity analyses, based on the six indicators outlined above. This process revealed a total of 61 Tier Three skills that registered as high intensity for at least one of the six indicators across all of the 12 Tier One Skills categories.

Table 25 Pyramid of sensitivity of skills shortages and requirements

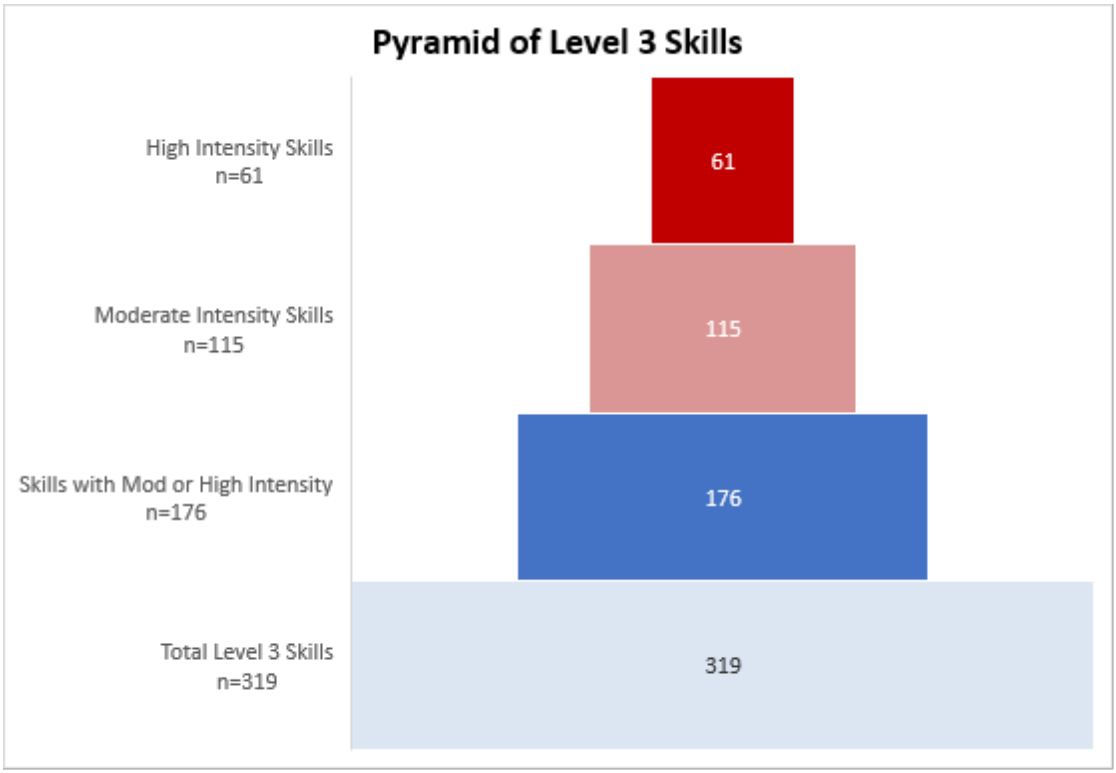


Table 25 above shows how the sensitivity analysis refined the data on the number of skills to determine a set of high intensity skills that are likely to be the key needs for Australia's space industry.

10.1 Aggregation of potential skills demand to identify additional high intensity needs

The sensitivity analyses that resulted in the 61 high intensity Tier Three skills were conducted independently for current shortages and future needs. When conducting an overall training needs analysis, it is also important for planners to consider current and future training requirements together. Hence, as step two of the sensitivity analyses process, the WSU and APAC team conducted additional sensitivity analyses using the aggregation of current shortages and future needs to assess overall demand and clarify the industry's training needs in a holistic manner. These aggregate sensitivity analyses highlighted an additional 25 high intensity Tier Three skills in one of two ways:

1. **Aggregated skills shortages –** There were an additional four Tier Three skills that did not initially register as high intensity, but which were identified as high intensity based on the sensitivity analyses using aggregated current shortages and future demand. These four skills appear to be required by more than double the number of organisations than those that currently employ these skills.

2. **Aggregated training provider gaps –** Aggregating the number of organisations with current and/or future demand for skills naturally places a higher demand on training providers. There were an additional 24 Tier Three skills that did not initially register as high intensity, but which were identified as high intensity skills where the ratio of organisations with current and/or future skills requirements per training provider was ten or more. This suggests a strong need for providers to review their capacity to be able to cater for current shortages and build capacity for the workforce of the future.

The results from the initial sensitivity analyses, combined with the analyses using aggregated current skills shortages and future needs, identified 86 high intensity Tier Three skills out of the total of 319 Tier Three skills, which are shown in detail in Table 27.

These 86 high intensity Tier Three skills are considered to be the principal skills needs identified by this study. They are comprised of skills with at least one high intensity area in current skills, current shortages, future skills needs, training provider gaps, aggregated current shortages and future needs, and training provider gaps in aggregated current shortages and future needs. The remainder of this section will focus on these 86 high intensity Tier Three skills needs.

10.2 Analysis of high intensity skills needs

Table 26 High Intensity Tier Three skills needs in each Tier One skills category

High Intensity skills needs in each Tier One skill category	Skills Needs
Category 1 - Launcher and Spacecraft Development	4
Category 2 - Satellite Payload and Sensor Development	0
Category 3 - Satellite Payload and Ground-based Technologies Development Technologies.	1
Category 4 - Space Exploration Technologies Development	15
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	17
Category 6 - Ground Systems Technologies and Services	10
Category 7 - Space Environment Monitoring Technologies	1
Category 8 - Space System Project Management	7
Category 9 - Software, Programming and Computer	12
Category 10 - Space Applications	6
Category 11 - Space Sector Enabling Skills	13
Category 12 - Soft Skills	0
TOTAL	**86**

Analysis of the data reveals that the below five skills categories each have ten or more high intensity skills needs:

- Category Five - Spacecraft Mechanisms, Structures and Materials Development (17)
- Category Four - Space Exploration Technologies Development (15)
- Category 11 - Space Sector Enabling Skills (13)
- Category Nine - Software, Programming and Computer Skills (12)
- Category Six - Ground Systems Technologies and Services (10)

These would appear to be strong candidates for further, more detailed investigation into the specific nature of the skills needs. For example, it is known that Australia has a high level of expertise in ground systems, and the fact that skills needs appear in this area may be a consequence of satellite communications providers not participating in this survey. However, there are new and emerging areas in ground systems, and it is therefore also possible that there are indeed significant needs in these areas. Further investigation will be required to understand the nature of these shortages.

The below four skills categories have only one or no high intensity skills needs:

- Category Three - Satellite Payload and Ground-based Technologies Development (1)
- Category Seven - Space Environment Monitoring Technologies
- Category Two - Satellite Payload and Sensor Development
- Category 12 - Soft Skills

While there are some moderate or low intensity needs in these categories, the lack of high intensity needs suggests they do not have the urgency of skills and training development found in other categories.

Table 27 provides details of the 86 Tier Three skills that have high intensity skills needs and/or training gaps. This table lists each of the skills that exhibit high intensity shortages in current skills, in future demand or with respect

to training provider shortages. It indicates the number of organisations which now have that skill, with the number of organisations identified by sector, multi-nationality, and size in terms of employees and revenue. It also highlights (in dark red) the sensitivity analysis factor/s that makes it a high priority area for further investigation by training providers and/or workforce planners. The table also indicates those high intensity skills areas of importance to the six SmartSat CRC Research Programs and Enabling Themes.

Table 27 Skills Sensitivity analysis of high intensity shortages

Skills Needs Analysis				Type of Organisation												Timing of Skills Shortage							CRC All 6 Areas
				Sector of organisations with current skills					Size of organisations - by revenue			Size of organisations - by staff numbers					Timing of High Intensity Skills Gaps			Timing of High Intensity Training Gaps				
			Number of Organisations employing Current Skills	Private	University	Gov	NFP	Multinational/ International	Large	Medium	Small	Large	Medium	Small	Micro	Number of Training/ Education Provider	Current Skills Shortage relative to current demand	Future Skills Demand relative to current Supply	Aggregated Current and Future Demand for TNA	Organisations with current Skills Shortage per Training Provider	Organisations with Future Skills demand per Training Provider	Aggregated Shortage or Future demand per Training Provider	CRC Intensity Areas Skills Requirements
1	Launcher and Spacecraft Development Skills		H=<3																				
1.1	**Propulsion Systems**																						
	1.1.2	Electric Space Propulsion	4	2	2	0	0	1	2	0	2	2	0	1	1	2		●	●				1
	1.1.4	Advanced Propulsion	3	0	3	0	0	0	2	1	0	3	0	0	0	3	●		●				0
1.3	**Guidance, Navigation & Control**																						
	1.3.3	Navigation Technologies	13	8	5	0	0	1	5	1	7	5	3	3	2	1						●	1
	1.3.5	GNC Systems Engineering Technologies	9	5	4	0	0	1	4	0	5	4	2	1	2	1					●	●	1
3	Satellite Payload and Ground Based Technologies Development Skills																						
3.4	**Optoelectronics**																						
	3.4.5	Quantum Technologies	4	0	4	0	0	0	3	1	0	4	0	0	0	3		●	●				2
4	Space Exploration Technologies Development Skills																						
4.2	**Autonomous Systems**																						
	4.2.3	Autonomous Rendezvous & Docking	3	0	2	1	0	0	2	1	0	3	0	0	0	2	●	●	●				0
4.3	**Planetary Body Exploration**																						
	4.3.1	Mission Infrastructure, Sustainability & Supportability	2	1	1	0	0	1	1	0	1	1	1	0	0	1	●	●	●		●	●	0
	4.3.2	Mission Operations and Safety	4	3	1	0	0	1	1	2	1	2	2	0	0	1	●	●	●		●	●	1
	4.3.3	Other Exploration Destination Systems	2	0	1	0	0	0	1	0	0	1	0	0	0	1	●	●	●		●	●	0
4.4	**Entry, Descent & Landing**																						
	4.4.1	Aeroassist & Atmospheric Entry	4	2	2	0	0	0	1	1	2	2	0	0	2	1			●			●	0
	4.4.2	Descent	5	2	3	0	0	0	2	1	2	3	0	0	2	1						●	0
	4.4.3	Landing	4	2	1	0	0	0	1	0	2	1	0	0	2	1	●		●			●	0
	4.4.4	Vehicle Systems	6	4	1	1	0	0	1	2	3	2	2	0	2	1						●	0
	4.4.5	Other Entry, Descent & Landing Systems	3	2	1	0	0	0	1	0	2	1	0	0	2	1		●	●			●	0
4.6	**Human Health, Life Support & Habitation Systems**																						
	4.6.1	Environmental Control, Life Support Systems & Habitation Syste	4	0	2	2	0	0	3	1	0	4	0	0	0	1	●	●	●			●	0
	4.6.2	Extravehicular Activity Systems	1	1	0	0	0	1	0	0	1	0	1	0	0	0	●	●	●	●	●	●	0
	4.6.4	Environmental Monitoring, Safety & Emergency Response	4	1	1	2	0	1	2	1	1	3	1	0	0	0	●		●	●	●	●	0
	4.6.7	Instrumentation in Support of Life Sciences	4	0	2	2	0	0	3	1	0	4	0	0	0	1	●		●			●	0
	4.6.8	Instrumentation in Support of Physical Sciences	4	0	2	2	0	0	3	1	0	4	0	0	0	1	●		●				0
	4.6.9	Applied Life Science Technology	3	0	2	1	0	0	2	1	0	3	0	0	0	1		●	●				0
5	Spacecraft Mechanisms Structures & Materials Development Skills																						
5.1	**Mechanisms**																						
	5.1.2	Non-Explosive Release Technologies	5	4	1	0	0	0	0	2	3	1	2	0	2	0					●	●	0
	5.1.4	Control Electronics Technologies	6	4	1	1	0	0	0	2	4	2	1	1	2	0					●	●	1
	5.1.5	MEMS Technologies	4	1	2	1	0	0	1	2	1	3	0	1	0	0					●	●	0
	5.1.6	Tribology Technologies	1	0	0	1	0	0	0	1	0	1	0	0	0	0	●	●	●	●	●	●	0
	5.1.8	Pyrotechnic Technologies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	●	●	●	●	●	●	0
	5.1.9	Flexible Capture Technologies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	●	●	●	●	●	●	0
	5.1.10	Other Mechanisms	3	2	0	1	0	0	0	1	2	1	1	1	0	0	●	●	●	●	●	●	0
5.2	**Structures**																						
	5.2.7	Launchers, Reentry Vehicles, Planetary Vehicles	4	3	1	0	0	0	0	2	2	1	1	0	2	0	●		●	●	●	●	0
	5.2.8	Crew Habitation, Safe Haven and EVA Suits	1	0	1	0	0	0	1	0	0	1	0	0	0	0	●	●	●	●	●	●	0
	5.2.9	Meteoroid and Debris Shield Design and Analysis	2	0	1	1	0	0	0	2	0	2	0	0	0	0	●	●	●	●	●	●	0
	5.2.10	Advanced Structural Concepts and Materials	7	3	3	1	0	0	2	3	2	4	2	0	1	1	●						0
	5.2.11	Other Structures	3	1	1	1	0	0	1	1	1	2	0	0	1	1							0
5.3	**Materials and Manufacturing Processes**																						
	5.3.1	Novel Materials and Materials Technology	9	4	4	1	0	0	3	2	4	5	1	1	2	1						●	0
	5.3.3	Cleanliness and Sterilisation	6	4	2	0	0	0	1	2	3	2	1	1	2	1	●						0
	5.3.9	Advanced Manufacturing Technologies	8	5	2	1	0	0	2	1	5	3	3	1	1	2			●				0
5.4	**Electrical, Electronic and Electro-mechanical (EEE) Components and Quality**																						
	5.4.1	Methods and Processes for Product Assurance of EEE Componen	5	2	3	0	0	0	2	1	2	3	0	0	2	0			●	●	●	●	2
	5.4.2	EEE Component Technologies	4	1	2	1	0	0	2	1	1	3	0	0	1	0	●	●	●	●	●	●	2

Skills Needs Analysis - Continued

				Type of Organisation												Timing of Skills Shortage						CRC All 6 Areas
				Sector of organisations with current skills					Size of organisations - by revenue			Size of organisations - by staff numbers					Timing of High Intensity Skills Gaps			Timing of High Intensity Training Gaps			
			Number of Organisations employing Current Skills	Private	University	Gov	NFP	Multinational/ International	Large	Medium	Small	Large	Medium	Small	Micro	Number of Training/ Education Provider	Current Skills Shortage relative to current demand	Future Skills Demand relative to current Supply	Aggregated Current and Future Demand for TNA	Organisations with current Skills Shortage per Training Provider	Organisations with Future Skills demand per Training Provider	Aggregated Shortage or Future demand per Training Provider	CRC Intensity Areas Skills Requirements
6	**Ground Systems Technologies & Services Skills**																					
6.1	**Ground Station Systems and Networks**																					
	6.1.4	Ground Station Software	18	10	5	2	1	4	5	6	6	9	6	2	1	1					●	●	1
6.2	**Mission Operations and Ground Data Systems**																					
	6.2.1	Advanced System and Mission Operation Concepts	14	10	3	1	0	4	3	5	6	7	5	0	2	1					●	●	1
	6.2.2	Mission Operations	16	10	3	1	1	3	3	3	9	6	3	3	3	1					●	●	1
	6.2.3	Ground Data Systems	16	11	4	1	0	5	4	6	5	8	6	1	1	0				●	●	●	1
	6.2.4	Other Mission Ops & Ground Data Technologies	10	6	3	1	0	3	4	2	4	5	4	0	1	0				●	●	●	1
6.3	**Ground, Test & Surface Systems**																					
	6.3.1	Infrastructure Optimisation	10	7	2	1	0	3	2	4	4	4	4	1	1	0				●	●	●	1
	6.3.2	Test & Qualification	20	14	3	1	1	5	2	7	10	6	8	2	3	2						●	2
	6.3.3	Assembly, Integration & Launch	13	8	3	0	1	2	2	3	7	4	4	1	3	2						●	2
	6.3.4	Mission Success Technologies	14	8	3	1	1	2	2	4	7	5	4	2	2	1					●	●	1
	6.3.5	Other Ground, Test & Surface Systems	10	8	2	0	0	2	2	2	6	2	6	0	2	1						●	1
7	**Space Environment Monitoring Technologies Skills**																					
7.2	**Space Situational Awareness**																					
	7.2.4	Debris Remediation and Protection	3	2	1	0	0	2	0	2	1	1	2	0	0	2	●	●	●				1
8	**Space System Project Management Skills**																					
8.1	**Management of Space Projects**																					
	8.1.1	Project Management of Space Projects	29	22	4	1	2	8	4	7	17	8	9	5	7	3						●	6
	8.1.2	Risk Management of Space Projects	26	21	2	1	1	8	2	7	15	6	9	4	6	3						●	6
	8.1.3	Systems Engineering Skills for Space Projects	29	21	5	1	1	7	5	7	15	9	10	3	6	3						●	6
8.3	**Quality, Dependability and Safety**																					
	8.3.1	System Dependability and Safety	17	13	2	0	1	4	3	5	8	5	5	3	3	1				●	●	●	4
	8.3.2	Software Quality	22	16	3	1	1	5	4	6	11	7	6	5	3	2						●	5
	8.3.3	Product and Quality Assurance	18	14	2	0	1	5	3	5	9	5	6	3	3	1				●	●	●	5
	8.3.5	Other Quality & Safety	13	10	3	0	0	4	4	3	6	5	5	1	2	1						●	4
9	**Software, Programming & Computer Skills**																					
9.1	**Software used with Space Systems**																					
	9.1.2	Space Segment Software	16	7	6	2	1	1	6	3	7	8	5	2	1	3	●						2
9.3	**Software, Modelling, Simulation & Information Processing**																					
	9.3.5	Mission Architecture, Systems Analysis & Concept Development	18	12	5	0	1	4	5	3	9	6	7	0	5	2						●	4
9.4	**Flight Dynamics and GNSS**																					
	9.4.1	Flight Dynamics (FD)	7	5	2	0	0	2	1	4	2	3	2	1	1	1			●			●	0
	9.4.2	GNSS High-Precision Data Processing	6	3	2	0	1	1	2	2	2	2	3	1	0	0	●		●	●	●	●	0
9.6	**Virtual Reality Technologies**																					
	9.6.3	Training techniques for space missions	5	2	3	0	0	2	3	1	1	3	2	0	0	2	●	●	●				0
	9.6.4	Virtual Reality for Long Distance Spaceflight	3	1	2	0	0	1	2	0	1	2	1	0	0	1	●	●	●			●	0
9.7	**Quantum Computing Technologies**																					
	9.7.1	Quantum Computing Techniques	3	1	2	0	0	1	3	0	0	3	0	0	0	2		●	●				2
	9.7.2	Quantum Cryptography	2	0	2	0	0	0	2	0	0	2	0	0	0	2		●	●				2
	9.7.3	Other Quantum Computing	2	0	2	0	0	0	2	0	0	2	0	0	0	2		●	●				2
9.8	**CyberSecurity & Resilience Technologies**																					
	9.8.1	Cybersecurity for Space Systems	12	8	4	0	0	2	5	2	5	6	5	0	1	2						●	4
	9.8.2	Resilience techniques for Space Systems	14	9	5	0	0	4	5	3	5	6	7	0	1	3	●						4
	9.8.4	Resilience techniques for Ground Systems	15	9	5	1	0	4	5	5	4	8	7	0	0	3	●						4
10	**Space Applications Skills**																					
10.1	**Satellite Communications Services & Applications**																					
	10.1.3	Direct to home television products and services	3	2	1	0	0	2	1	1	0	1	2	0	0	1							0
	10.1.4	Mobile Satellite Communications	7	5	2	0	0	1	2	2	2	3	3	1	0	1						●	1
10.3	**Global Positioning, Navigation and Timing Services & Applications**																					
	10.3.2	Satellite navigation service providers, GNSS Services	6	2	3	0	1	2	3	0	2	3	2	0	1	1	●		●			●	0
	10.3.3	Provision/exploitation of sat based location data	7	2	4	0	1	1	4	1	2	5	1	0	1	1	●		●			●	0
	10.3.4	GIS data integration & analysis	11	7	3	0	1	4	4	2	5	6	1	1	3	1						●	0
	10.3.5	IT & software for satnav data manipulation	7	2	3	1	1	1	3	3	1	6	1	0	0	1						●	0
11	**Space Sector Enabling Skills**																					
11.1	**Regulation and essential service delivery**																					
	11.1.2	Space related policy making	17	8	6	2	1	2	7	2	7	10	1	1	5	3	●						1
11.4	**Specialised Space-Related Support Services**																					
	11.4.1	Launch and satellite insurance (including brokerage)	5	2	1	0	1	0	1	0	3	1	1	2	0	2	●		●				0
	11.4.2	Specialised space-related legal and/or contract management ski	11	8	2	1	0	3	3	3	5	5	2	1	3	3	●						5
	11.4.4	Risk management, audit and assurance skills	12	9	3	0	0	2	4	2	6	5	3	1	3	2	●					●	1
	11.4.5	Economic analysis and review skills	9	7	1	0	1	2	2	1	6	2	4	2	1	1						●	1
	11.4.6	Financial skills	9	9	0	0	0	2	1	1	6	1	4	2	2	1						●	0
	11.4.7	Business development skills	20	11	4	3	2	4	6	2	10	8	5	2	5	2						●	0
	11.4.8	Sales and marketing skills	14	9	3	1	1	4	4	2	7	5	5	1	3	0				●	●	●	0
	11.4.9	Media management skills including social media	13	9	2	1	1	3	3	2	7	4	5	1	3	1						●	1
	11.4.11	Market research services	6	6	0	0	0	1	1	1	4	1	3	1	1	0	●			●	●	●	0
	11.4.12	Consultancy services	15	10	3	0	2	2	4	1	10	5	2	1	7	4							0
	11.4.13	Health services for astronaut health or space specific medical se	4	1	2	0	1	0	2	0	2	2	0	1	1	3	●		●				0
	11.4.15	Working with, responding to and engaging with Government	18	9	6	1	2	4	6	2	8	8	4	2	4	1						●	6

Table 28 indicates the number of high intensity Tier Three skills in each Tier One Skills Category that are relevant to the activities undertaken through the six SmartSat Research Programs and Enabling Themes. The data reveals that 41 of the 86 high intensity Tier Three skills across 10 Tier One Skills categories are of particular interest to SmartSat.

Table 28 High intensity skills needs of importance to SmartSat research programs

Category	Skills Needs
Category 1 - Launcher and Spacecraft Development	3
Category 2 - Satellite Payload and Sensor Development	0
Category 3 - Satellite Payload and Ground-based Technologies Development	1
Category 4 - Space Exploration Technologies Development	1
Category 5 - Spacecraft Mechanisms, Structures and Materials Development	3
Category 6 - Ground Systems Technologies and Services	10
Category 7 - Space Environment Monitoring Technologies	1
Category 8 - Space System Project Management	7
Category 9 - Software, Programming and Computer Skills	8
Category 10 - Space Applications	1
Category 11 - Space Sector Enabling Skills	6
Category 12 - Soft Skills	0
TOTAL	**41**

Sensitivity analysis of this data indicates that the below four categories have six or more high intensity needs and are likely to be of most importance to SmartSat:

- Category Six - Ground Systems Technologies and Services (10)
- Category Nine - Software, Programming and Computer Skills (8)
- Category Eight - Space System Project Management (7)
- Category 11 - Space Sector Enabling Skills (6).

10.3 Identifying current training providers for high intensity skills and/or training gaps

Further analysis was conducted on the 86 high intensity Tier Three skills to identify the organisations that provide training for each of these skills and to identify any provider gaps. The results are shown in Table 29. This table lists each of the 86 Tier Three skills that exhibit high intensity shortages in current skills, future demand, or with respect to training providers. It indicates the number of organisations that can provide training for each skill. Using a matrix format, it shows the training organisations by sector and indicates which of the 86 Tier Three skills that each can provide training for, where the training capabilities are highlighted in dark red. The table also indicates those high intensity skills areas of importance to SmartSat.

Table 29 Training providers for high intensity skills

Training Providers for High Intensity Skills		Number of Training/ Education Providers	CRC Priority Areas Skills Requirements	Universities								Private Sector			Non-Profit	
				University 1	University 2	University 3	University 4	University 5	University 6	University 7	University 8	Private Organisation 1	Private Organisation 2	Private Organisation 3	Not for Profit Organisation1	Not for Profit Organisation2
1 Launcher and Spacecraft Development Skills																
1.1 Propulsion Systems																
1.1.2	Electric Space Propulsion	2	1				*	*								
1.1.4	Advanced Propulsion	3	0	*			*		*							
1.3 Guidance, Navigation & Control																
1.3.3	Navigation Technologies	1	1				*									
1.3.5	GNC Systems Engineering Technologies	1	1				*									
3 Satellite Payload and Ground Based Technologies Development Skills																
3.4 Optoelectronics																
3.4.5	Quantum Technologies	3	2		*		*	*								
4 Space Exploration Technologies Development Skills																
4.2 Autonomous Systems																
4.2.3	Autonomous Rendezvous & Docking	2	0				*	*								
4.3 Planetary Body Exploration																
4.3.1	Mission Infrastructure, Sustainability & Supportability	1	0	*												
4.3.2	Mission Operations and Safety	1	1	*												
4.3.3	Other Exploration Destination Systems	1	0	*												
4.4 Entry, Descent & Landing																
4.4.1	Aeroassist & Atmospheric Entry	1	0				*									
4.4.2	Descent	1	0				*									
4.4.3	Landing	1	0				*									
4.4.4	Vehicle Systems	1	0				*									
4.4.5	Other Entry, Descent & Landing Systems	1	0				*									
4.6 Human Health, Life Support & Habitation Systems																
4.6.1	Environmental Control, Life Support Systems & Habitation Syste	1	0					*								
4.6.2	Extravehicular Activity Systems	0	0													
4.6.4	Environmental Monitoring, Safety & Emergency Response	0	0													
4.6.7	Instrumentation in Support of Life Sciences	1	0					*								
4.6.8	Instrumentation in Support of Physical Sciences	1	0					*								
4.6.9	Applied Life Science Technology	1	0					*								
5 Spacecraft Mechanisms Structures & Materials Development Skills																
5.1 Mechanisms																
5.1.2	Non-Explosive Release Technologies	0	0													
5.1.4	Control Electronics Technologies	0	1													
5.1.5	MEMS Technologies	0	0													
5.1.6	Tribology Technologies	0	0													
5.1.8	Pyrotechnic Technologies	0	0													
5.1.9	Flexible Capture Technologies	0	0													
5.1.10	Other Mechanisms	0	0													
5.2 Structures																
5.2.7	Launchers, Reentry Vehicles, Planetary Vehicles	0	0													
5.2.8	Crew Habitation, Safe Haven and EVA Suits	0	0													
5.2.9	Meteoroid and Debris Shield Design and Analysis	0	0													
5.2.10	Advanced Structural Concepts and Materials	1	0		*											
5.2.11	Other Structures	1	0		*											
5.3 Materials and Manufacturing Processes																
5.3.1	Novel Materials and Materials Technology	1	0		*											
5.3.3	Cleanliness and Sterilisation	1	0		*											
5.3.9	Advanced Manufacturing Technologies	2	0		*											
5.4 Electrical, Electronic and Electro-mechanical (EEE) Components and Quality																
5.4.1	Methods and Processes for Product Assurance of EEE Componen	0	2													
5.4.2	EEE Component Technologies	0	2													
6 Ground Systems Technologies & Services Skills																
6.1 Ground Station Systems and Networks																
6.1.4	Ground Station Software	1	1												*	
6.2 Mission Operations and Ground Data Systems																
6.2.1	Advanced System and Mission Operation Concepts	1	1	*											*	
6.2.2	Mission Operations	1	1													
6.2.3	Ground Data Systems	0	1													
6.2.4	Other Mission Ops & Ground Data Technologies	0	1													
6.3 Ground, Test & Surface Systems																
6.3.1	Infrastructure Optimisation	0	1													
6.3.2	Test & Qualification	2	2									*			*	
6.3.3	Assembly, Integration & Launch	2	2									*			*	
6.3.4	Mission Success Technologies	1	1												*	
6.3.5	Other Ground, Test & Surface Systems	1	1									*				

Training Providers for High Intensity Skills Continued			Number of Training/ Education Providers	CRC Priority Areas Skills Requirements	Universities								Private Sector			Non-Profit	
					University 1	University 2	University 3	University 4	University 5	University 6	University 7	University 8	Private Organisation 1	Private Organisation 2	Private Organisation 3	Not for Profit Organisation1	Not for Profit Organisation2
7	**Space Environment Monitoring Technologies Skills**																
7.2	**Space Situational Awareness**																
	7.2.4	Debris Remediation and Protection	2	1	*					*							
8	**Space System Project Management Skills**																
8.1	**Management of Space Projects**																
	8.1.1	Project Management of Space Projects	3	6	*					*						*	
	8.1.2	Risk Management of Space Projects	3	6	*					*						*	
	8.1.3	Systems Engineering Skills for Space Projects	3	6	*					*						*	
8.3	**Quality, Dependability and Safety**																
	8.3.1	System Dependability and Safety	1	4												*	
	8.3.2	Software Quality	2	5		*										*	
	8.3.3	Product and Quality Assurance	1	5												*	
	8.3.5	Other Quality & Safety	1	4								*					
9	**Software, Programming & Computer Skills**																
9.1	**Software used with Space Systems**																
	9.1.2	Space Segment Software	3	2				*			*						
9.3	**Software, Modelling, Simulation & Information Processing**																
	9.3.5	Mission Architecture, Systems Analysis & Concept Development	2	4		*		*								*	
9.4	**Flight Dynamics and GNSS**																
	9.4.1	Flight Dynamics (FD)	1	0						*							
	9.4.2	GNSS High-Precision Data Processing	0	0													
9.6	**Virtual Reality Technologies**																
	9.6.3	Training techniques for space missions	2	0	*				*								
	9.6.4	Virtual Reality for Long Distance Spaceflight	1	0					*								
9.7	**Quantum Computing Technologies**																
	9.7.1	Quantum Computing Techniques	2	2		*		*									
	9.7.2	Quantum Cryptography	2	2		*		*									
	9.7.3	Other Quantum Computing	2	2		*		*									
9.8	**CyberSecurity & Resilience Technologies**																
	9.8.1	Cybersecurity for Space Systems	2	4		*			*								
	9.8.2	Resilience techniques for Space Systems	3	4	*	*		*									
	9.8.4	Resilience techniques for Ground Systems	3	4	*	*		*									
10	**Space Applications Skills**																
10	**Satellite Communications Services & Applications**																
	10.1.3	Direct to home television products and services	1	0									*				
	10.1.4	Mobile Satellite Communications	1	1					*								
10	**Global Positioning, Navigation and Timing Services & Applications**																
	10.3.2	Satellite navigation service providers, GNSS Services	1	0				*									
	10.3.3	Provision/exploitation of sat based location data	1	0				*									
	10.3.4	GIS data integration & analysis	1	0				*									
	10.3.5	IT & software for satnav data manipulation	1	0				*									
11	**Space Sector Enabling Skills**																
11	**Regulation and essential service delivery**																
	11.1.2	Space related policy making	3	1		*	*	*									
11	**Specialised Space Related Support Services**																
	11.4.1	Launch and satellite insurance (including brokerage)	2	0		*	*							*			
	11.4.2	Legal and/or contract management skills	3	5		*	*								*		
	11.4.4	Risk management, audit and assurance skills	2	1		*	*										
	11.4.5	Economic analysis and review skills	1	1			*										
	11.4.6	Financial skills	1	0			*										
	11.4.7	Business development skills	2	0			*								*		
	11.4.8	Sales and marketing skills	0	0													
	11.4.9	Media management skills including social media	1	1										*			
	11.4.11	Market research services	0	0													
	11.4.12	Consultancy services	4	0					*					*	*		*
	11.4.13	Space specific medical services	3	0					*			*					*
	11.4.15	Working with, responding to and engaging with Government	1	6					*								

Table 30 - Tier three skills with no training providers as identified in the survey

Category Four - Space Exploration Technologies Development	
4.6.2	extravehicular activity systems
4.6.4	environmental monitoring, safety and emergency response
Category Five - Spacecraft mechanisms, structures and materials development skills	
5.1.2	non-explosive release technologies
5.1.4	control electronics technologies
5.1.5	MEMS technologies
5.1.6	tribology technologies
5.1.8	pyrotechnic technologies
5.1.9	flexible capture technologies
5.1.10	other mechanisms
5.2.7	launchers, re-entry vehicles, planetary vehicles
5.2.8	crew habitation, safe haven and Extravehicular Activity (EVA) suits
5.2.9	meteoroid and debris shield design and analysis
5.4.1	methods and processes for product assurance of EEE components
5.4.2	EEE component technologies
Category Six - Ground Systems Technologies and Services Skills	
6.2.3	ground data systems
6.2.4	other mission operations and ground data technologies
6.3.1	infrastructure optimisation
Category Nine - Software, Programming and Computer Skills	
9.4.2	GNSS high-precision data processing
Category 11 - Space Sector Enabling Skills	
11.4.8	specialised space-related sales and marketing skills
11.4.11	specialised space-related market research services

The remaining 66 high intensity Tier Three skills had only 13 training providers identified in total. The maximum number of training providers for any specific Tier Three skill is four, which occurred only once, and 38 Tier Three skills had only one training provider identified. This indicated that 58 of the 86 high intensity Tier Three skills (67%) had one or less training provider and suggests additional training providers may be needed.

Table 29 indicates that eight universities and five organisations in the private (3) and not-for-profit sectors (2) comprise those training providers that identify capability in developing training for these skills. These results indicate that the greatest capacity for developing these skills is currently in the university sector. It also seems to suggest that, in general, non-university providers tend to specialise in a select few skills, while universities are able to train over a broader range of skills.

SmartSat Research Programs and Enabling Themes may also be affected by the low number of training providers for these high intensity skills. Table 31 identifies 25 high intensity skills that might be needed for SmartSat programs, but which currently have only one training provider or less.

Table 31 High intensity skills relevant to SmartSat with one or fewer training providers

		Number Training Providers	SmartSat CRC Programs
Category One - Launcher and Spacecraft Development			
1.3.3	navigation technologies	1	1
1.3.5	GNC systems engineering technologies	1	1
Category Four - Space Exploration Technologies Development			
4.3.2	mission operations and safety	1	1
Category Five - Spacecraft Mechanisms, Structures and Materials Development			
5.1.4	control electronics technologies	0	1
5.4.1	methods and processes for product assurance of EEE components	0	2
5.4.2	EEE component technologies	0	2
Category Six - Ground Systems Technologies and Services Skills			
6.1.1	ground station systems	1	1
6.1.2	ground communication networks	1	1
6.1.3	ground station equipment	1	1
6.1.4	ground station software	1	1
6.1.5	other ground station technology	1	1
6.2.1	advanced system and mission operation concepts	1	1
6.2.2	mission operations	1	1
6.2.3	ground data systems	0	1
6.2.4	other mission operations and ground data technologies	0	1
6.3.1	infrastructure optimisation	0	1
6.3.4	mission success technologies	1	1
6.3.5	other ground, test and surface systems	1	1
Category Eight - Space System Project Management Skills			
8.3.1	system dependability and safety	1	4
8.3.3	product and quality assurance	1	5
8.3.5	other quality and safety	1	4
Category 10 - Space Applications Skills			
10.1.4	mobile satellite communications	1	1
Category 11 - Space Sector Enabling Skills			
11.4.5	specialised space-related economic analysis and review skills	1	1
11.4.9	specialised space-related media management skills incl. social media	1	1
11.4.15	specialised space-related skills for working and engaging with government	1	6

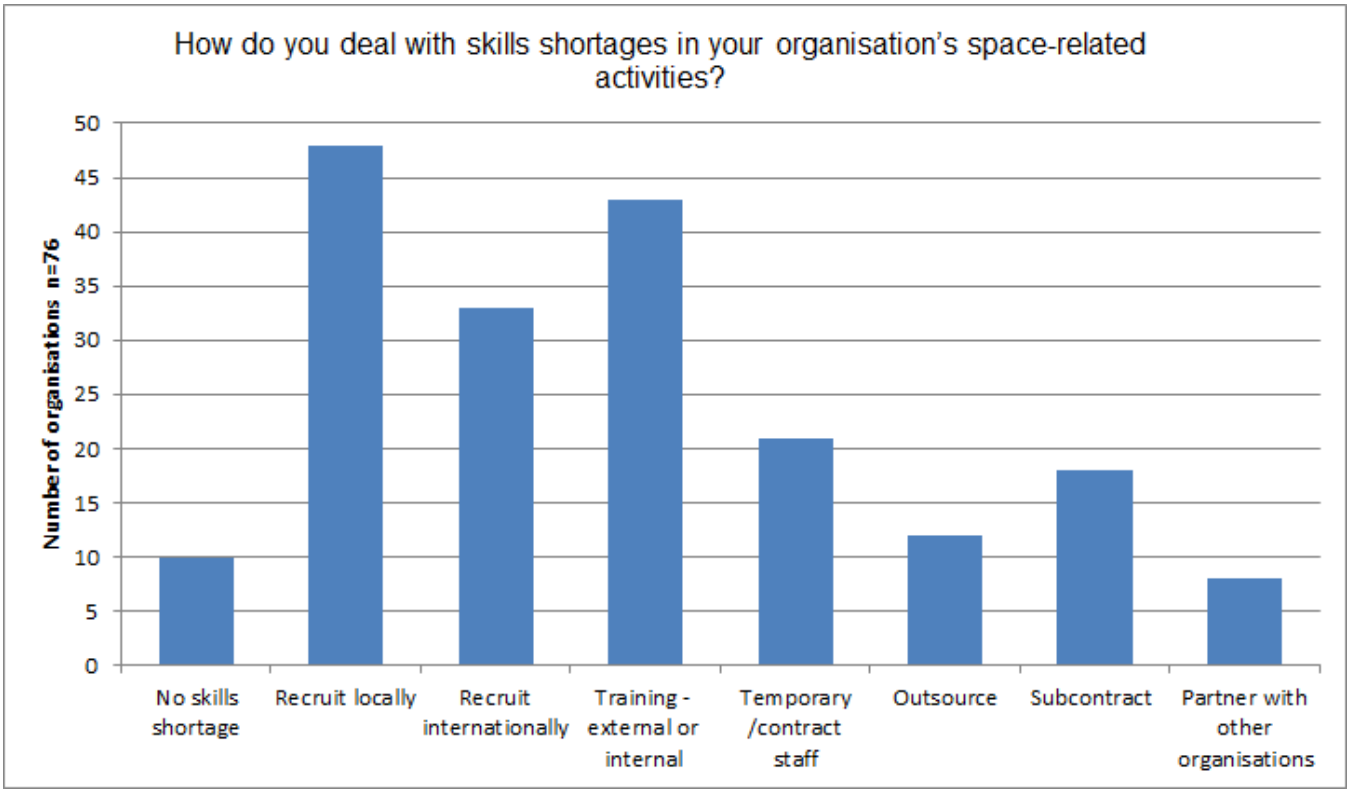
11.0 Findings on industry responses to skills shortages

All organisations must have a strategy to address current or potential skills shortages in order to pursue their organisational objectives. To understand the current range of practices in dealing with this issue, respondents were asked to identify how they deal with shortages in their space-related activities. They were asked to select all methods they used to address shortages from a range of the below options:

- my organisation has not encountered skills shortages for its space-related activities
- recruit locally
- recruit internationally
- recruit to a suitable competency and build capability through training or on-the-job learning
- bring on temporary contract or freelance staff
- outsource to another organisation
- subcontract to another organisation
- other

This question was answered by 77 respondent organisations, representing 86% of those completing the survey. The results are shown in Table 32.

Table 32 Respondent organisations' methods of responding to skills shortages



When faced with a space-related skills shortage, most respondents recruit locally, with 62% indicating this is one of their options. Although this approach was stated as the most frequently used method, it is surprising that more organisations do not use this approach. Even after assuming that the 13% of respondent organisations that indicate no current skills shortage would use this approach, the number of organisations adopting this approach would only reach 75%, which seems low for job recruitment in Australia. This would suggest that space skills shortages are more difficult to address in Australia, to the point where some organisations have to find other

means of employing the skills they require.

11.1 Alternatives to local recruitment to fill skills shortages

These fall into two broad categories:

1. **Developing skills through training and on-the-job experience.**

   Recruiting locally to a lower competency standard, and then developing the skills through training and on-the-job learning, is a strategy used by 56% of the respondent organisations. This is not surprising given the highly technical nature of many space-related job skills. Anecdotal evidence confirms that many organisations believe that, due to the highly specific nature of many space-related skills, it can be more expedient to train staff internally than to fill the skills from the open job market.

2. **Finding other sources of people with the relevant skills**

   Organisations source staff from other organisations or locations in a number of ways to overcome the inherent time and cost disadvantages of training staff:

   - International recruitment - 43% of respondent organisations indicated that they use this approach. This seems relatively high for job recruitment in Australia, which again suggests that space skills shortages are more difficult to address within Australia to the point where organisations look overseas to address them.

   - Using the resources of other local organisations - the appointment of temporary or contract staff is used by 27% of respondents, while 26% subcontract work to another organisation and 16% outsource sections of their work to alleviate shortages.

   - Collaboration with other organisations - Interestingly, in a remarkable exhibition of a common thread, 10% of organisations selected the 'other' category and said they seek to collaborate with, team or partner with other organisations to address their shortages. The geographical scope of this approach is not limited to Australia, as 3% of respondents indicated they seek out international organisations to obtain the necessary skills. This suggests that collaboration, partnership, and teaming are a significant method of addressing space-related skills needs in the Australian space industry.

11.2 Training as a strategy to address shortages

The fact that 56% of respondent organisations use training - either external or in-house – to address shortages represents a significant opportunity for that part of the Australian education and training sector capable of meeting those needs for the space industry.

This is highlighted in the 22 open-ended comments about the specific strategies that organisations use to address current shortages or future needs. Half of the comments indicated that training was one of the key methods used to address these current shortages or future needs. This included external and in-house training, sometimes conducted by external experts. Some also indicated that they sought international training for their staff. Mentorship by experts was referred to as a training and development method by 23% of those organisations that provided open-ended comments, while internship programs were mentioned by 14% of respondents as a method of attracting high-calibre individuals and growing them into specialised roles within their organisation. Collaboration and partnership also featured highly in the open-ended comments, with 18% of the comments referring to this concept.

One respondent organisation described its strategy as attracting international specialist talent to move to Australia and finding generalist talent in-country. Anecdotal evidence suggests this strategy is used widely across the Australian space community.

11.3 International recruitment as a strategy to grow industry skills

Recruitment of specialist skills from overseas has long been one of the key methods used by Australian organisations to address space skills gaps, shortages, and needs. Table 32 shows that recruiting Internationally is the third most prolific option used by respondent organisations (after recruiting locally and training), with 43% of the 76 respondents to this question (37% of the 90 respondents to the survey) recruiting staff from overseas.

Respondents were asked to indicate the space-related skills they had recruited from overseas. Table 33 lists those skills obtained via international recruitment by the 23 respondent organisations that provided detailed information for this question. Note that many of these organisations have sourced more than one space-related skill from overseas.

Table 33 Space-related skills recruited internationally by respondent organisations

Basic Skills Shortages
· Applied Physics Skills
· Engineering and Programming Skills
· Environmental processes understanding
· Space Research Leads
Remote Sensing/Earth Observation Skills Shortages
· Earth Observation Analyst
· Remote Sensing Algorithms
· Biophysical earth observation data processing (including field, geospatial and image data collection and processing)
Position, Navigation & Timing Skills Shortages
· GNSS-PNT Skills
· PNT Skills
Engineering Skills Shortages
· Space Engineering
· Space Electronics
· Experienced Space Engineers
· Aerospace Component Design
· Aerospace Component Qualification & Testing
· Skills in Internet of Things
· Neuromorphic Engineering
Satellite Communications Skills Shortages
· Antenna Design
· RF Payload Design
· RF Payload Testing
Software Skills Shortages
· Firmware Engineer
· Software Engineer
· Machine Learning Skills
· Skills in Machine Learning Techniques
· Machine Learning Expertise
· Coding and Advanced Machine Learning
· Artificial Intelligence
Manufacturing Skills Shortages
· Hybrid Additive Manufacturing Expertise
· Advanced Manufacturing Skills
· Low Volume, High Quality Manufacturing Skills
Launch Activities Skills Shortages
· Launch Specialists
· Launch Vehicle research, development, design & test
· Launch Vehicle Manufacturing
· Guidance, Navigation and Control Engineering
· Avionics Engineering
· Software Engineering
· Aerospace Structures Engineering
Technical Skills Shortages
· Astrodynamics Skills
· Aerospace Surface Finishing
· Atmospheric Modelling
· Orbit Determination Skills
· Technical hardware expertise in Product design for customised applications
· Successful deployment in space experience (Orbital monitoring and control operations of in-orbit attitude control thrusters)
Management Skills Shortages
· International Project Controls
· Regulatory Compliance
· Individuals with space experience and government experience
· Program Management
· Space law, space policy, space security (law and policy, soft skills), education

APAC has conducted three previous major studies of Australia's space industry for the Australian Government in 2010[18], 2011[19] and 2015-16[20]. Each of these studies included the same questions about recruitment of staff from overseas, and the skills obtained from overseas, as were used in this study, which enables a direct comparison of the results.

In each of these studies, the skills recruited from overseas fall into the same general areas:

- basic and academic skills
- remote sensing/earth observation
- position navigation and timing
- engineering
- satellite communications
- technical skills
- management skills

Compared to the previous studies, the respondent organisations indicated a similar profile of skills obtained from overseas in all of the space-related skills areas above. In addition, this study indicated a marked increase in overseas recruitment of skills in space-related software, manufacturing and launch activities, to the extent that these now warrant inclusion as separate categories. This is consistent with the evolving nature of space activities in general and the specific space activities developing in Australia.

There are now several organisations seeking to develop launch sites in Australia which explains the demand for skills related to launch activities, regulatory compliance, and space law. Additive manufacturing and advanced manufacturing offer potential competitive advantages in launch vehicle and spacecraft manufacturing and are being pursued by the industry worldwide, as well as in Australia.

The importance of understanding and cataloguing space debris and the growing importance of space situational awareness, as well as potential launch activities, is driving the demand for astrodynamics and orbit determination skills. Space-related software skills are emerging as a key skills area worldwide, particularly in machine learning and artificial intelligence. These software skills are also in demand for the development of remote sensing algorithms and processing earth observation data, as well as enhanced position, navigation, and timing solutions.

The respondent organisations were also asked to indicate the main countries from which they had sourced space-related skills from overseas. This same data was obtained in the three previous APAC studies cited above. Table 34 shows the countries from which Australian organisations recruited staff with space-related skills for APAC's 2010, 2011, 2015-16 studies, as well as the current study. This table also indicates the number of times a particular country was mentioned as a source of recruitment of space-related skills to Australia.

[18] A Review of Current Australian Space Activities, Asia Pacific Aerospace Consultants. 2010.
[19] A Review of Current Australian Space Activities, Asia Pacific Aerospace Consultants, 2011.
[20] A Selective Review of Australian Space Capabilities: Growth Opportunities in Global Supply Chains and Space Enabled Services, Asia Pacific Aerospace Consultants, 2015-16.

Table 34 Countries from which Australian organisations have recruited space-related skills

APAC 2010 Aust Space Industry Study			APAC 2011 Aust Space Industry Study			APAC 2016 Aust Space Industry Study			WSU/APAC 2021 SmartSat CRC Study		
50 Respondents of 194 Total		26%	77 Respondents of 346 Total		22%	22 Respondents of 46 Total		48%	23 Respondents of 90 Total		26%
Country	Named for O/S Recruits	% of Total	Country	Named for O/S Recruits	% of Total	Country	Named for O/S Recruits	% of Total	Country	Named for O/S Recruits	% of Total
USA	9	14%	USA	17	15%	USA	3	15%	USA	13	19%
UK	7	11%	UK	13	12%	South Africa	3	15%	UK	8	11%
Germany	7	11%	Germany	12	11%	Belarus	1	5%	China	6	9%
Canada	6	9%	Europe	8	7%	Canada	1	5%	France	5	7%
Europe	6	9%	Canada	7	6%	China	1	5%	Canada	4	6%
France	6	9%	France	7	6%	Colombia	1	5%	Europe	4	6%
Japan	4	6%	India	5	5%	Europe	1	5%	Germany	4	6%
India	3	5%	Japan	5	5%	France	1	5%	India	4	6%
New Zealand	3	5%	Russia	5	5%	Germany	1	5%	Spain	4	6%
South Africa	3	5%	South Africa	5	5%	India	1	5%	New Zealand	3	4%
Belgium	2	3%	China	4	4%	Ireland	1	5%	Netherlands	2	3%
Asia	1	2%	Belgium	3	3%	Israel	1	5%	Pakistan	2	3%
Bulgaria	1	2%	Denmark	3	3%	New Zealand	1	5%	Asia	1	1%
China	1	2%	New Zealand	3	3%	Singapore	1	5%	Brazil	1	1%
Denmark	1	2%	Asia	2	2%	South East Asia	1	5%	Estonia	1	1%
Indian Subcontinent	1	2%	Italy	2	2%	UK	1	5%	Greece	1	1%
Italy	1	2%	Spain	2	2%				Iran	1	1%
Philippines	1	2%	Bulgaria	1	1%				Italy	1	1%
Russia	1	2%	Indian Subcontinent	1	1%				Middle East	1	1%
Spain	1	2%	Iran	1	1%				Norway	1	1%
Sweden	1	2%	Nepal	1	1%				South Africa	1	1%
			North America	1	1%				South Korea	1	1%
			Philippines	1	1%				Southeast Asia	1	1%
			Sweden	1	1%						
			Ukraine	1	1%						
Total	66		Total	111		Total	20		Total	70	

An average of 25% of respondent organisations across this study and the three previous APAC studies cited above have recruited staff from overseas to fill space related skills gaps and needs.

Table 34 indicates that the United States is consistently the most cited country for recruitment by Australian organisations to fill gaps and shortages. The US was named as the source of international staff by 14% - 19% of respondents, depending on the study. The United Kingdom is ranked second, generally being named by 11% - 12% of respondents depending on the study, followed closely by Germany.

The top six most mentioned countries - USA, UK, Germany, France, Canada, Europe - have been relatively consistent across the four studies as the source of recruits for Australian organisations. New Zealand and South Africa also remain active recruitment sources. One noticeable change in the last five years is the movement of China into the top six recruitment sources, based on the results of this study. It appears that China has partially replaced Europe as a recruitment location although there is still substantial recruitment from European nations. India and the Indian subcontinent (Pakistan, Sri Lanka, Nepal, and Bangladesh) also represent a major and consistent recruitment base from Asia. Japan was historically a large recruitment source but has diminished in this regard in recent years. This is also the case with Russia and Eastern Europe, which were previously active recruitment locations but were not mentioned as a current source by respondent organisations for this study.

11.4 Outreach activities as a strategy to grow industry skills

Outreach activities are recognised as a viable means of attracting new talent to Australia's space industry and inspiring students to pursue STEM courses to prepare them to fill shortages in the sector.

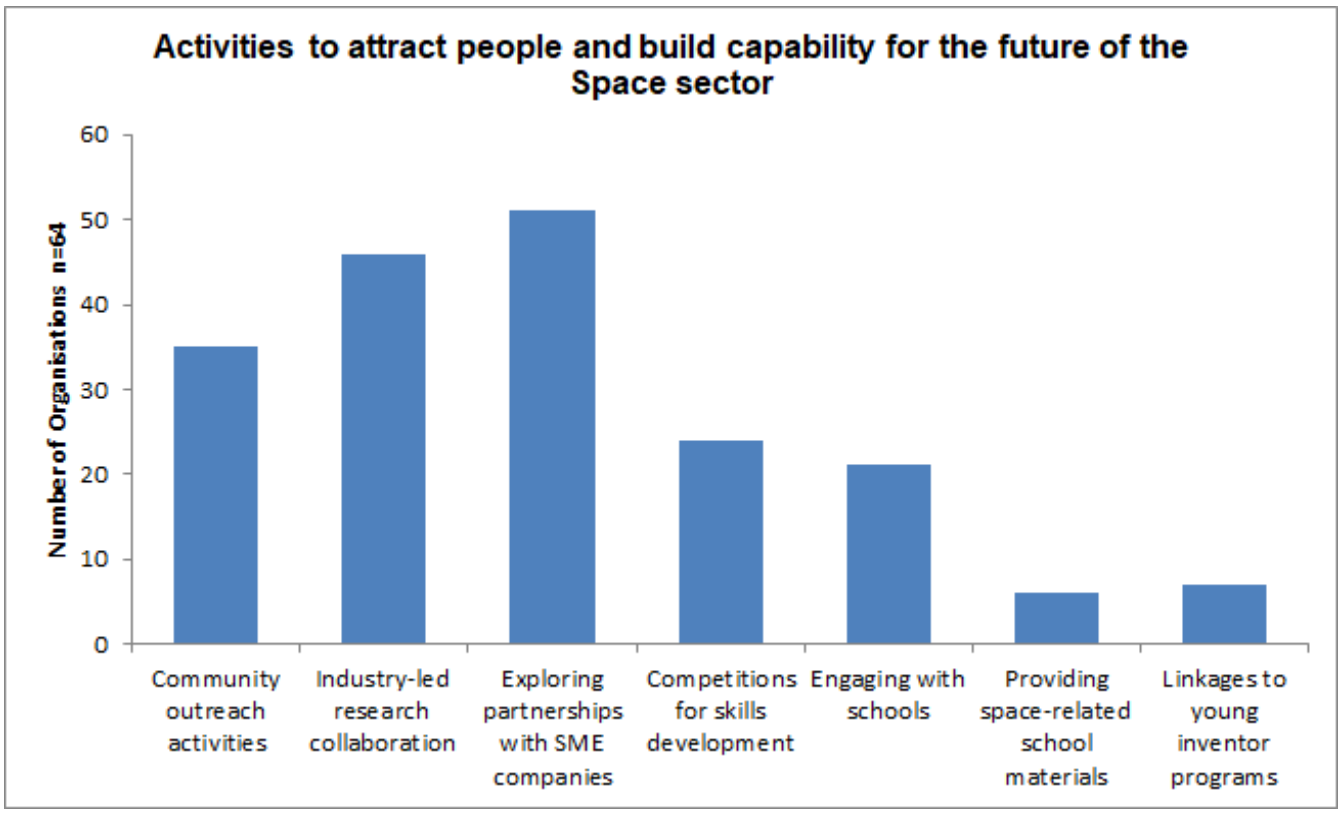
The *2018 Expert Reference Group Review of Australia's Space Industry Capability (Expert Reference Group Report)* highlighted the importance of building a sizeable, suitably trained workforce as a critical element in enabling Australia's growing space ambitions. That report recognised the importance of outreach activities in attracting students into STEM programs, as well as attracting the highly qualified workforce needed by the space industry.

To assess whether the industry was using outreach activities as a long-term strategy to address potential shortages, respondents were asked to indicate whether they conducted a range of such activities to attract people and build capability for the future. They were asked to indicate whether they conducted any of the below activities, each of which were derived from the *Expert Reference Group Report*:

- space-inspired STEM community outreach activities
- industry-led research collaboration with research institutions to underpin the space industry
- exploring partnerships with small- and medium-sized companies to participate in global supply chains for the space industry
- initiating or supporting competitions for development of innovative technology, applications, and skills
- engaging with schools on global space activities
- developing or providing space-related course materials to schools for K-12 students and teachers
- linkages to existing young inventor programs, such as the Young Scientist Awards.

Figure 9 displays the results of the data on outreach activities conducted by the 64 organisations that responded to this question.

Figure 9 Outreach activities conducted by respondents



The data indicates that 64 (71%) of the 90 respondent organisations that answered this question conduct some form of outreach activity. The 64 respondents to this question are collectively involved in all seven outreach activities derived from the *Expert Reference Group Report*. The high numbers of participants and range of activities suggest that Australia's space industry recognises outreach activities as an important strategy towards building a sizeable, suitably trained workforce.

The most common activity is exploring partnerships with SMEs, with 51 (80%) organisations indicating they are involved in this. The next most common activity is industry-led research collaboration, with 46 (72%) of respondent organisations involved. These two outreach activities have partnerships and collaboration at their core, which was highlighted in Sections 11.1 and 11.2 as a key strategy to address shortages. The high number of organisations indicating their involvement in these activities confirms this is a widely used strategy.

The third most used outreach activity is space-inspired STEM community outreach, with 35 (55%) respondent organisations involved. This is again a high percentage, which suggests space industry recognition of the importance of STEM activities to build the future workforce and community support for space activities.

This data shows that the importance of engaging people at an early age is recognised and practiced by the Australian space industry, with a number of outreach activities focused on this direction. Initiating and supporting competitions to develop innovation and skills is undertaken by 24 (38%) of respondent organisations, while linkages to young inventor programs are supported by 7 (11%), engaging with schools on global space activities by 21 (33%), and providing space-related school materials is undertaken by 6 (9%) of respondent organisations.

This data clearly demonstrates that Australia's space industry is heavily engaged in outreach activities to attract new people as an important long-term strategy towards building a sizeable, suitably trained workforce.

12.0 Training and education provider profiles

An important aspect of this study was to identify training organisations that could provide services for current skills shortages and future needs in the space industry, and to understand the type of organisations. Respondent organisations were asked to indicate if they were training providers and were given the opportunity to nominate and describe the types of training they could provide. This section will describe the profiles of providers that participated in the survey, and the types of skills development services and programs they offer.

A total of 46 (51%) respondent organisations indicated they were a provider of space-related skills development, training or education to improve capability for the space industry (referred to as a training provider in this study). This indicates that Australia's space industry is well-equipped to develop skills, with more than half of the survey participants identifying as a provider.

The survey was structured with two places for organisations to indicate their capabilities as a training provider:

1. the taxonomy section - providers could indicate that they currently offer training services for a specific skill

2. the training and education provider section - providers could give a more detailed description and profile of the types of training and education programs they offer.

In practice, however, not all training providers completed both sections:

- In the taxonomy responses – 26 organisations identified as a training provider by indicating those skills in the taxonomy for which they can provide training

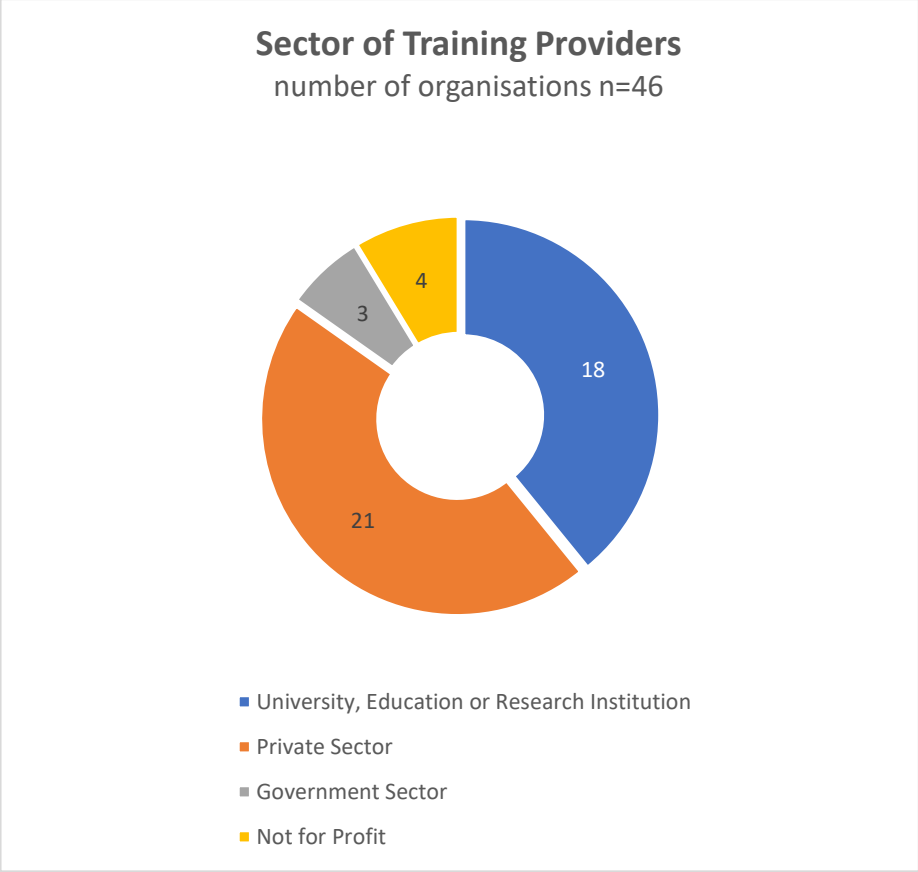
- In the training and education provider section, 45 respondents completed specific questions about their training and education programs. One respondent organisation completed the taxonomy section but did not complete this section, and they have been identified as providing undergraduate and postgraduate programs for the purposes of this section of the study

It is interesting to note that, of the 21 survey responses from the university sector, only 12 identified as training providers in the taxonomy. Six universities identified as training providers in the training and education provider section but not in the taxonomy. There were three university respondents that did not identify as training providers anywhere in the survey, and hence are not counted as providers in this study.

12.1 Profiles of training providers

As indicated in Figure 10, the largest number of training provider respondent organisations were from the private sector, with 21 (46%) of organisations, followed by the university sector with 18 (39%), not-for-profits with 4 (9%), and government with 3 (7%) organisations. It is interesting to note that, in this survey, more non-university sector organisations indicated training capability than universities. This is an essential point as these sectors are an important source for job skills training. It is clear that industry-based training can and does play a significant role in addressing space-related skills shortages.

Figure 10 Training providers by sector



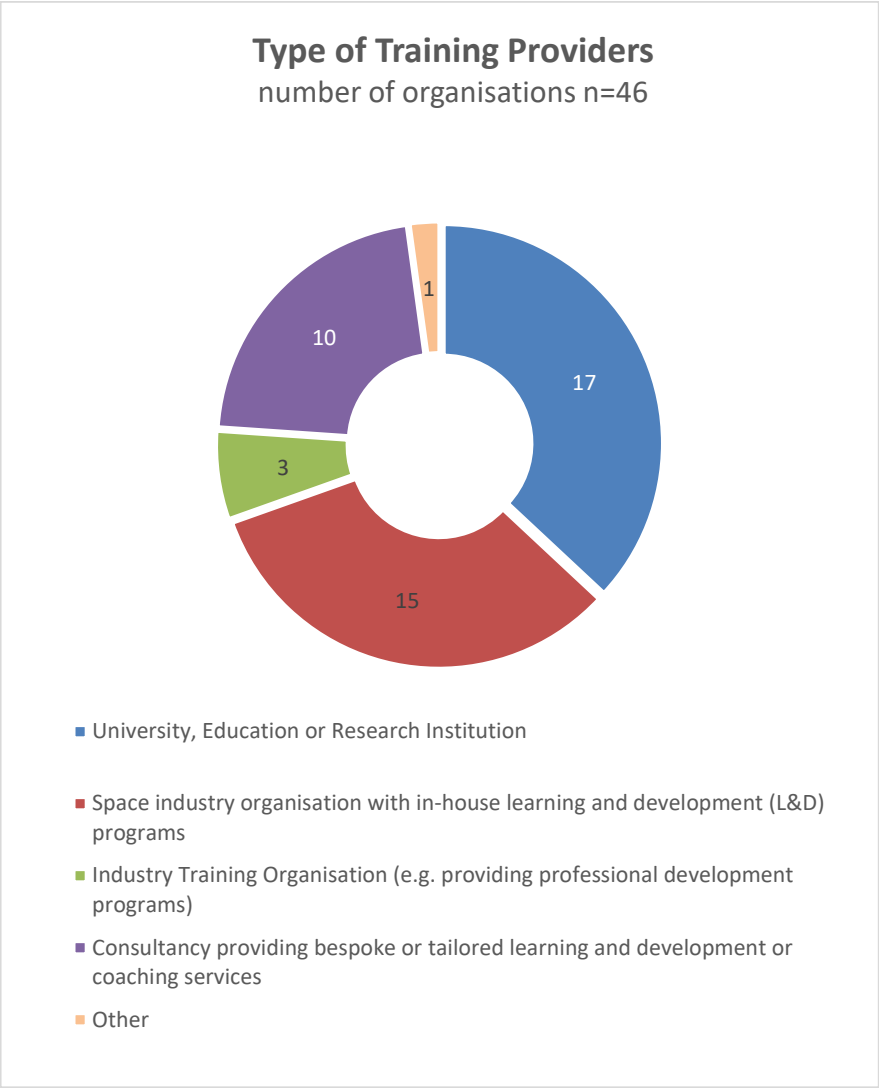
The respondents that identified as training providers were asked to identify the primary type of training they provide from the below options:

- university, education or research institution
- TAFE
- vocational (non-TAFE)
- space industry organisation with in-house learning and development programs
- industry training organisation (e.g., providing professional development programs)
- consultancy providing bespoke or tailored learning and development or coaching services
- other.

As indicated in Figure 11, the types of training providers are dominated by university programs, with 17 (37%) of universities identifying undergraduate or postgraduate programs. There is a similar proportion (33%) of 15 in-house training providers. There were three (7%) industry training providers and ten (22%) providers offering bespoke programs. One training provider identified itself as providing a different category of funding training and education institutes to develop and deliver programs. These findings appear to further corroborate the previous findings in Section 10 that many organisations use in-house or private training providers for skills development. It is also likely that industry training organisations and small consultancies specialising only in training and development are under-represented in this study.

A further, more detailed study of training providers focused on high intensity skills shortages may uncover more organisations providing services to the space industry. Furthermore, there are a plethora of organisations that offer more generic training and development in the more pervasive skills, such as soft skills, project management etc.

Figure 11 Training providers by type



The TAFE or vocational education sector did not have any representation in this study. This is clearly an area for future study to ascertain what relevant TAFE or vocational programs may exist to address shortages in the industry. One training provider indicated that it offers apprenticeships in space science areas, and it is likely that further study may identify other organisations that offer this type of space-related job skills training.

12.1.2 Training providers by location

As indicated in the graph below, the location of training providers is very similar to the industry at large, with most located in NSW, and a fairly even distribution of others through Victoria, Queensland, the Australian Capital Territory and South Australia. One SmartSat CRC member located overseas also identified itself as a training provider. Eight (17%) of the training providers are part of a multinational organisation.

Figure 12 Training providers by location

12.1.3 Size of training providers

As indicated in Figure 13, nearly half (48%, 22 organisations) of the training providers tended to be large organisations with more than 200 staff, as would be expected with universities (18) and larger organisations providing in-house programs. Of interest is the proportion of small and micro-sized organisations which make up 28% (13 organisations) of the providers, indicating that even small organisations see a role in training in this industry. This is likely centred around a specific skills-set or a specialty held by these smaller organisations that is recognised as valuable by others.

When organisation size is measured by revenue, the largest proportion (41%) of training providers are small organisations as defined by the Australian Bureau of Statistics, with less than A$10 million revenue per annum (19 organisations). Only 15 (33%) of the training providers are defined as large organisations, with revenues over A$250 million per annum, while 10 (22%) of the organisations are defined as medium sized. The predominance of small organisations by revenue is common across the Australian space industry.

The data, which is based on size of the training organisation, suggest that larger organisations with more staff and revenue have greater capacity to develop or purchase training programs. These findings also suggest that non-university-based development of skills is provided by smaller organisations that can provide industry-specific or highly tailored programs.

Figure 13 Size of training providers by staff

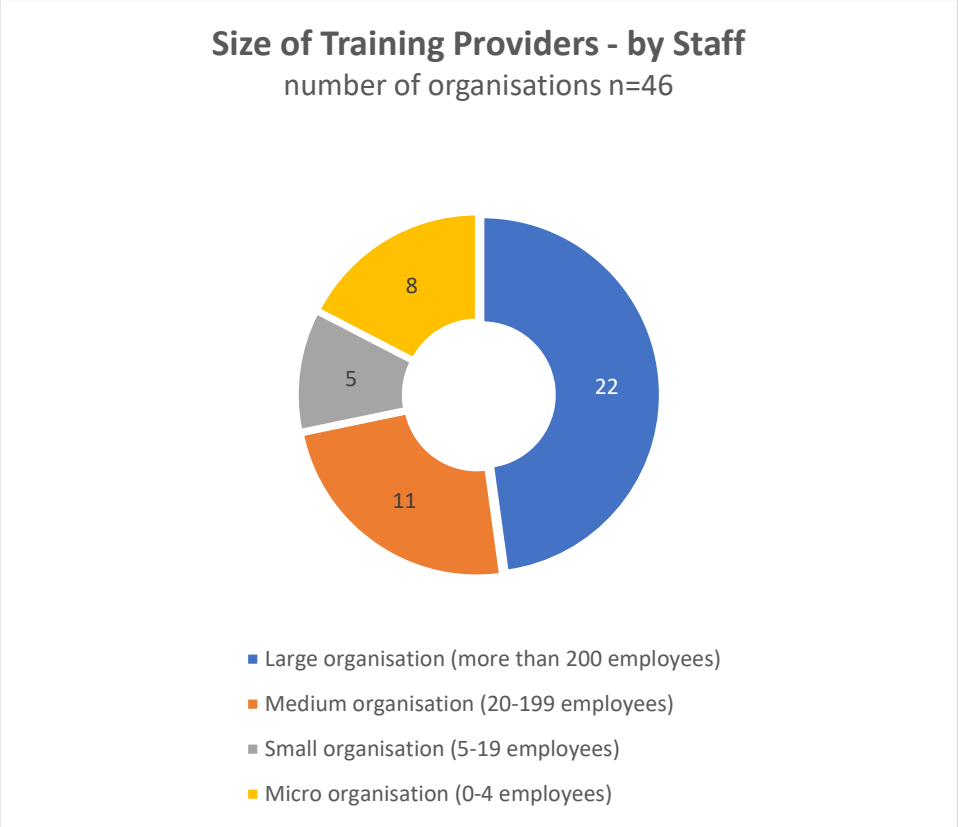
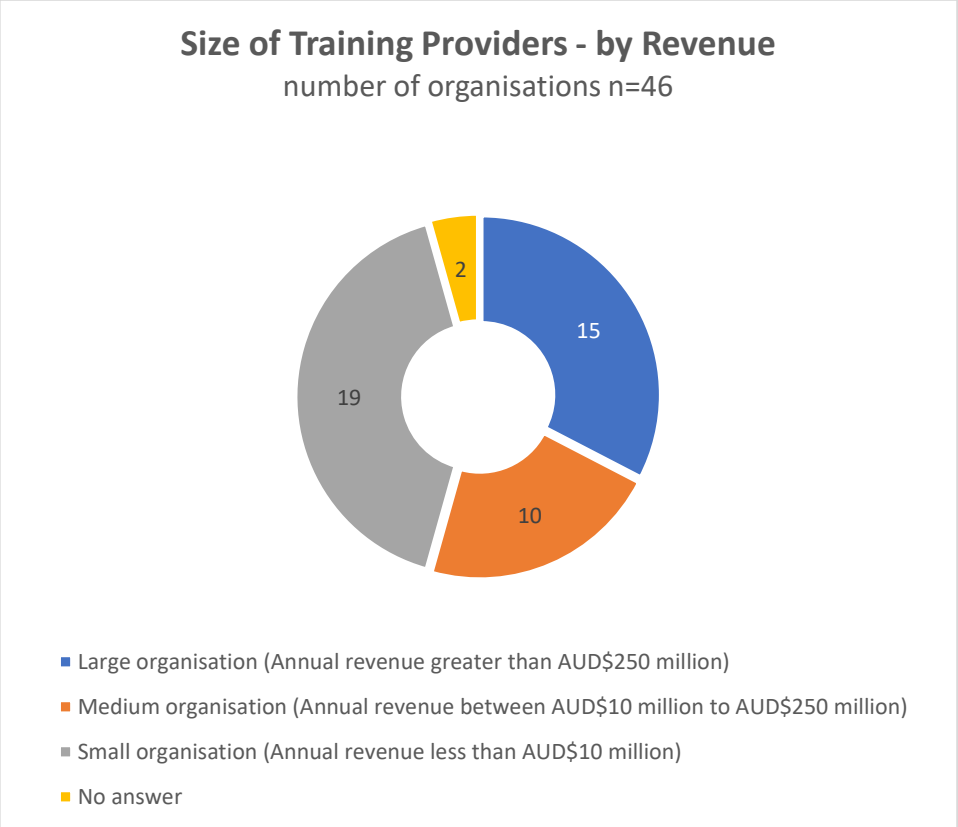


Figure 14 Size of training providers by revenue



12.2 Organisations which identified as training providers for skills in the taxonomy

Training providers were invited to identify the Tier Three skills that they could train for in the taxonomy section of the survey. A total of 26 organisations indicated they had the ability to provide training for specific skills in the taxonomy. Table 35 indicates the number of training providers capable of delivering training for some aspect of each of the Tier One skills categories used in the taxonomy. This data shows that every Tier One category has a minimum of four providers that can supply training for some of the skills in that category.

Table 35 Training providers capable of delivering Tier One skills category training

Training and education providers by skills category	Training/ Education Providers indicated in Taxonomy
Category 1 - Launcher and Spacecraft Development	8
Category 2 - Satellite Payload and Sensor Development	10
Category 3 - Satellite Payload and Ground-Based Technologies Development	10
Category 4 - Space Exploration Technologies Development	8
Category 5 - Spacecraft Mechanisms, Structures, and Materials Development	4
Category 6 - Ground Systems Technologies and Services	6
Category 7 - Space Environment Monitoring Technologies	8
Category 8 - Space System Project Management	7
Category 9 - Software, Programming, and Computer Skills	13
Category 10 - Space Applications	10
Category 11 - Space Sector Enabling Skills	15
Category 12 - Soft Skills	18
TOTAL Responses	**26**

A more detailed summary of the capabilities of the 26 organisations that identified as training providers relative to the skills in the taxonomy is provided in Table 36.

Table 36 Summary of training provider capabilities

Sector	Providers	State	Number of skills offered per Skills Category												High Intensity Skill Gaps Offered
			1 - Launcher &Spacecraft Development	2 - Satellite Payload & Sensor Development	3 - Satellite Payload &Ground Based Technologies Development	4 - Space Exploration Technologies Development	5 - Spacecraft Mechanisms, Structures & Materials Development	6 - Ground Systems Technologies & Services	7 - Space Environment Monitoring Technologies	8 - Space System Project Management	9 - Software, Programming &Computer	10 - Space Applications	11 - Space Sector Enabling	12 - Soft Skills	
		26	8	10	10	8	4	6	8	7	13	10	15	18	13
University	University 1	ACT							1				13	14	7
	University 2	WA	3	2	13	17		1	9	9	22		12	33	12
	University 3	VIC									12				
	University 4	VIC	17	2	2	23	19	2	6	4	34	8	11	45	18
	University 5	SA	33	1	25	28			5		34	15	16	45	25
	University 6	NSW							3				2	2	
	University 7	QLD				4		1		2	9		1	12	2
	University 8	SA	19	9	25	21	3			6	13	4	18	37	15
	University 9	NSW		1	13						2		4	29	
	University 10	NSW			4										
	University 11	NSW	17	8	4				4	8	3			12	7
	University 12	NSW		6		2			2		12		3	6	1
Private	Private Organisation 1	NSW									6	5		11	
	Private Organisation 2	QLD											3		
	Private Organisation 3	ACT			1			2				1			
	Private Organisation 4	NSW			15			5				6			5
	Private Organisation 5	NSW	1				3			6				5	
	Private Organisation 6	NSW	1											5	
	Private Organisation 7	NSW		1							1	5	4	27	3
	Private Organisation 8	SA											1		
	Private Organisation 9	NSW											1	29	3
Non-Profit	Not for profit Organisation 1	NSW												16	
	Not for profit Organisation 2	VIC										1			
	Not for profit Organisation 3	VIC	15	5	3	5	2	7		11	1	5	9	44	12
	Not for profit Organisation 4	VIC				1			3				5	37	2
Gov	Government Organisation 1	ACT		4							13	8			

Table 36 groups the 26 training organisations by sector and indicates the number of Tier Three skills in each Tier One skills category where the training provider can provide training (shaded in blue). The sensitivity analyses

described in Section 10 identified 86 high intensity skills needs. The final column shows the number of those high intensity skills needs (shaded in red) where each provider has indicated they have the capability to provide training.

Table 36 provides a high-level view of the broad areas of skills shortages that various training providers can address. The data shows that the capabilities of training providers range from broad offerings to skills in highly specialised areas. For example, three providers cover 10 or more of the 12 Tier One skills categories, while six specialise in one to three categories only.

Further analysis indicates that the breadth of the training skills seems to be concentrated in universities. One university indicates that it has training capability for skills in every Tier One skills category. A total of eight training providers indicated an ability to provide training for Tier Three skills in six or more Tier One skills categories. Seven of these eight organisations are universities, while the other one is associated with a university. Conversely, none of the private sector training organisations indicates a capability in more than five Tier One skills categories. This suggests that the private sector training providers tend to focus more on the specific skills areas that they possess in-house, while the university sector has greater ability to train across a broader number of areas.

From the perspective of total numbers, Tier One Skills Category One (Soft Skills) stands out, with 18 training providers indicating the ability to train in this area. Also standing out are Skill Category 11 (Space Sector Enabling Skills) with 15 organisations, and Category Nine (Software, Programming, and Computer Skills) with 13 organisations. Category Six (Ground Systems Technologies and Services) had six organisations and Category Five (Spacecraft Mechanisms, Structures, and Materials Development), with four organisations, had the lowest number of training providers.

The data indicates that high intensity skills shortage areas have a relatively large number of training providers, with 13 training organisations indicating the ability to train for some skills in these areas. Further detailed work is needed to identify in more depth the collective ability of providers to train for the high intensity shortage areas.

While this analysis can provide a high-level picture of where the skills training capabilities are located, further study is needed to assess these results. For example, it is known that Australia has strong capabilities and experience in ground systems for space operations, yet this is indicated as a Tier One Skills Category with one of the lowest number of training providers. This probably indicates that many of the training organisations that serve the satellite communications industry did not participate in the survey and further work is needed to verify whether there is an actual training provider shortage in this area.

It is important to reiterate that 20 organisations that identified as training providers in the survey did not indicate the specific skills in the taxonomy that they can train for. Each of these 20 organisations later indicated that they employed current skills listed in the taxonomy, suggesting that they do have the capacity to train against some of these skills. One organisation did not complete any of the Tier Two or Tier Three skills in the taxonomy.

Fifteen of these 20 organisations were among the 41 that provided only one answer to each skill in the taxonomy (as described in section 7.2 above), and hence did not differentiate between currently employed skills and those where they could provide training. It could reasonably be assumed that many of these organisations could provide training for skills in the taxonomy if they had selected more than one of the four options to indicate that they are a training provider and further work is needed to clarify the training capabilities of these organisations.

Furthermore, there are likely to be many more training providers for generic skills, such as soft skills and project management, that did not participate in the survey. This suggests further study is necessary to better map the training capabilities against high intensity skills needs for the Australian space industry.

12.3 Education, training and development programs offered by respondent organisations

Providers were invited to give a more detailed description and profile of the type of training and education programs they provide in the Training and Education Provider Section of the survey. A summary of the types of current training activities undertaken by each of the 46 providers, as well as their future training plans for space-related training, are indicated in Table 37.

Table 37 Summary of education, training and development programs offered by respondents

				Current programs						
Sector	Provider	State	Provider Type	Postgraduate	Undergraduate	Vocational	Professional Development	In House Learning and Development	Bespoke L&D or coaching programs	Future Programs
	46			20	18	1	16	15	12	33
University and Research Sector	University 1	ACT	University	*	*		*			*
	University 2	WA	University	*	*			*		*
	University 3	SA	University		*					*
	University 4	NSW	University	*	*					*
	University 5	VIC	University	*	*					
	University 6	VIC	University	*	*		*	*	*	*
	University 7	SA	University	*	*					*
	University 8	NSW	University	*	*					*
	University 9	QLD	University	*	*					*
	University 10	QLD	University	*						*
	University 11	QLD	University	*						
	University 12	SA	University	*			*		*	*
	University 13	NSW	University	*	*					
	University 14	NSW	University	*	*					*
	University 15	NSW	Industry Training Org	*	*		*			*
	University 16	NSW	University		*					*
	University 17	NSW	University	*						
	University 18	NSW	University				*			*
Private Sector	Private Organisation 1	VIC	In-house					*		*
	Private Organisation 2	ACT	Bespoke Programs					*		
	Private Organisation 3	ACT	In-house	*	*					*
	Private Organisation 4	SA	Bespoke Programs				*	*		*
	Private Organisation 5	NSW	In-house				*			
	Private Organisation 6	NSW	In-house				*			
	Private Organisation 7	QLD	Bespoke Programs					*		*
	Private Organisation 8	NSW	Bespoke Programs						*	
	Private Organisation 9	ACT	In-house					*		
	Private Organisation 10	ACT	In-house				*		*	*
	Private Organisation 11	QLD	Bespoke Programs						*	*
	Private Organisation 12	NSW	In-house				*	*		*
	Private Organisation 13	NSW	In-house					*		*
	Private Organisation 14	QLD	In-house				*			*
	Private Organisation 15	NSW	In-house	*	*		*	*	*	*
	Private Organisation 16	NSW	Bespoke Programs						*	
	Private Organisation 17	SA	In-house		*			*		
	Private Organisation 18	SA	Bespoke Programs						*	*
	Private Organisation 19	Tokyo	In-house					*		*
	Private Organisation 20	NSW	In-house					*		
	Private Organisation 21	NSW	Bespoke Programs				*	*	*	
Non-Profit	Not for Profit Organisation 1	NSW	Bespoke Programs						*	*
	Not for Profit Organisation 2	VIC	Industry Training Org				*			*
	Not for Profit Organisation 3	VIC	Industry Training Or	*	*		*			*
	Not for Profit Organisation 4	VIC	Bespoke Programs						*	*
Gov	Government Organisation 1	ACT	In-house	*						*
	Government Organisation 2	NSW	In-house	*	*	*	*	*	*	*
	Government Organisation 3	WA	Other							*

This data clearly shows the breadth of offerings for space-related training, with each of the below training activities available to the Australian space industry:

- postgraduate courses
- undergraduate courses
- vocational courses
- professional development
- in-house learning and development
- bespoke learning and development or coaching programs
- future programs.

Postgraduate courses were the activity referred to most often, with 20 organisations (43%) involved in this activity, followed by undergraduate courses with 18 organisations (39%) involved. It should be noted that some non-university training providers also listed themselves in these categories, by virtue of offering internships or degree-based research through their workplace activities in collaboration with universities. It is interesting to see the industry supporting the university sector through these internships and research programs. Six (13%) non-university organisations indicated that they partner with universities to support postgraduate and undergraduate degrees through projects, research projects and internships.

Sixteen organisations (35%) offer professional development programs, 15 organisations (33%) provide in-house or on-the-job training, and 12 organisations (26%) offer bespoke or tailored learning programs.

Even though no responses to the survey were received from the vocational sector, one organisation identified that they provided vocational programs through apprenticeships. It is certainly likely that other vocational programs relevant to space-related skills might be uncovered through future studies that specifically examine the capabilities of the vocational sector to deliver training for space-related skills.

The respondent organisations indicated that 33 (72%) of the training providers have specific plans and programs under development to deliver additional space-related training in the future.

12.4 Further work

This profile of the space-related training providers in Australia provides a clear picture of a broad range of providers delivering a wide variety of space-related training programs. However, the sensitivity analysis data also reveals there are potential gaps in training capabilities for some current and future skills needs.

However, it is also clear that this information on providers capable of training against the space-related skills shortages in Australia's space industry is incomplete. There are a number of universities, and specialised faculties within universities, that are known to have training capabilities and programs for space-related skills, but which did not complete the survey, including some members of SmartSat consortium. Additionally, there are no survey responses from TAFEs or other vocational institutions. Given these circumstances, it is clear that this survey has only captured an initial snapshot of the complex training picture for space-related skills in Australia. This data represents a good starting point, but further work will be necessary to fully understand the complete picture of the potential training providers for space-related skills to support the Australian space sector.

13.0 Conclusion

This study is a detailed and in-depth examination and assessment of Australian space-related skills. It examined current space-related skills and shortages, future requirements, and potential training providers for these shortages through the lens of a detailed, three-layer, custom-built ASST specifically designed for this study.

This three-tiered taxonomy included 319 specific Tier Three skills relevant to the Australian space industry, including technical skills, technology-specific skills and soft skills related to the higher education, professional development, and vocational education sectors. The primary data used in the study was collected through an online survey specifically designed to collect data on Australia's space industry job skills needs by reference to the ASST.

The survey elicited 90 valid responses, with a good distribution across the various sectors – 62% from the private sector, 23% from the university sector, 9% from the government sector and 6% from the not-for-profit sector, which broadly matches the current make-up of the Australian space industry. There were respondents from every state and territory of Australia except Tasmania and from a mix of large organisations (26%), medium organisations (21%) and small organisations (51%), measured by revenue.

Using this data, the study identified the key current and potential future skills needs across the Australian space industry, as well as key skills needs relevant to SmartSat's three major Research Programs and three Enabling Themes. The study also identified training providers that could deliver training for the various skills needs and identified areas where there might be a shortage of training providers for specific skills.

13.1 Key findings on current skills and shortages

This study has revealed some interesting and unexpected information about current skills and current and future needs:

1. Current skills exist within Australia's space industry for virtually all of the 319 Tier Three space-related skills in the ASST:

    - The 90 respondent organisations to the survey indicated that they collectively already have 317 (99%) of the 319 Tier Three skills in the ASST. This suggests that Australia already has a tremendous breadth of skills across virtually the entire spectrum.

2. Current skills shortages exist in virtually all of the 319 Tier Three space-related skills:

    - The 90 survey respondent organisations indicated that current shortages exist in 310 (97%) of the 319 Tier Three skills. This indicates there is a pervasive skills shortage.

3. There are future requirements in all 319 Tier Three skills.

4. Sensitivity Analyses identified 86 Tier Three skills as being of high intensity, based on current and future demand versus current skills and available training providers for specific skills.

5. Sensitivity analyses identified that 41 (48%) of the 86 high intensity Tier Three skills are required by SmartSat research programs or enabling themes.

The fact that there are current skills and skills shortages for almost every skill is an unexpected finding. The data also indicates that all 319 Tier Three skills will be required in the future and are expected to be in short supply. This suggests an industry which is poised for growth but cannot keep up with skills demand. It also suggests there

may be potential imbalances between skills capability and shortages across the Australian space industry, plus a need for training to address current shortages and future requirements.

The information provided via the survey makes the skills sensitivity analysis very simple – there are future needs for all 319 Tier Three skills and all except nine have current shortages. However, the fact that skills needs exist in all areas does not provide the type of information and level of detail this study was intended to provide. Hence sensitivity analyses were conducted to determine levels of intensity for skills demand versus current available skills, and shortages versus available training providers.

These sensitivity analyses identified 86 high intensity skills out of the 319 Tier Three skills. These represent skills with the highest shortfalls between current supply against current and future demand and are a logical place to start when considering the development of current and future training needs.

The 86 high intensity Tier Three skills were reviewed in the context of the skills required by SmartSat Research Programs and Enabling Themes. A mapping of these high intensity skills against the expected requirements of the various activities of SmartSat indicated that these research programs may require as many as 41 of those high intensity Tier Three skills where there is a shortage in supply. These 41 high intensity Tier Three skills represent a natural focal point for SmartSat in its consideration of future space-related skills development.

13.2 Key findings on training providers

This study also explored providers that might be able to deliver training and skills development for space-related skills needs. Some of these key findings include:

1. Of 90 respondent organisations, 46 (51%), spread across all of Australia, indicated they could provide some form of training for space-related skills development, training, or education.

2. The largest number of training provider respondent organisations were from the private sector (46%), with 39% from the university sector, 9% from the not-for-profit sector, and 7% from government.

3. Providers of university undergraduate or postgraduate programs were the most frequently referred to training activity (37%), while in-house training comprised 33%, bespoke training programs 22%, and industry training programs comprised 7% of training providers.

4. No training providers from the TAFE or vocational sector participated in the survey.

5. Only 26 training providers identified skills in the ASST for which they can provide training, while 45 respondent organisations completed specific questions about their training and educations programs.

6. Of the 86 high intensity Tier Three skills, 67% have one or no training providers identified in the survey (20 have no training provider identified, 38 have one training provider identified).

7. There are 25 high intensity skills that might be required for SmartSat research programs that have only one or no training provider.

The data indicates that there are some potential gaps in training providers for space-related skills. In addition, the training needs for such a large skills-set seems to rest with a handful of providers, often relying on in-house training programs. Only 13 training providers have any ability to deliver training for some of the 86 high intensity skills, and this training capability does not cover all 86 skills – there are no training providers for 20 of these skills.

The burden of trying to train for current shortages and future demand is likely to put further pressure on providers

and may lead to additional provider shortages and gaps. It is therefore likely that the space-related skills training sector will require:

- more training programs, and
- more training provider capacity.

Further work will be necessary to identify in more depth the collective ability for providers to deliver sufficient training in high intensity shortage areas and to cater for the training needs of the growing Australian space industry.

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