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## **Catalyzing Space Industries: Lessons learned from New Zealand on building entrepreneurial space ecosystems in developing and emerging countries**

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### **Abstract**

Space plays a vital role in addressing global challenges and has the potential to create an abundant future. The greatest societal benefit from space requires shared participation and opportunities for people across the world. Exponential technologies have reduced the barriers to participation in both upstream and downstream space industries, and open opportunities for global participation. The key to creating equitable global space opportunities is the development of entrepreneurial space ecosystems.

We have spent the past five years supporting the development of the entrepreneurial space ecosystem in New Zealand. The New Zealand space economy has grown to employ more than 5000 and generates more than NZ\$1.7B per year – similar to the New Zealand wine industry. We took a systemic approach of building the space ecosystem by involving multiple stakeholders from government, industry, academia and other sectors to collaborate on both top-down and bottom-up initiated activities. Each Individual and organization has a potential role to play in co-creating the local space industry.

Our lessons and methodology for catalyzing the local New Zealand space industry include a systemic approach to community building, prize challenges, education, incubators, startup mentoring, and government engagement. We have developed a capability assessment tool and workshop to identify the strengths and needs to develop a local space industry in other regions. Each local country or region faces specific challenges to creating a sustainable entrepreneurial space ecosystem.

We present initial results from workshops with participants from more than 40 countries that helped them identify actions they can take to grow their local entrepreneurial space industries. Some simple actions from a few individuals can catalyze an entrepreneurial space ecosystem and enable a region to participate in space opportunities. Currently we are scaling up this effort to involve other nations and regions and are already seeing adoption in other countries. Space offers tremendous opportunities that the entire world must share, and entrepreneurship is the key element for regions to achieve the benefits of space.

**Keywords:** Entrepreneurial Ecosystem, Space Industry, Developing Countries, New Zealand, Lessons Learned

### **Acronyms/Abbreviations**

AI: Artificial Intelligence

COPUOS: Committee on the Peaceful Uses of Outer Space

GPS: Global Positioning System

IoT: Internet of Things

IPCC: Intergovernmental Panel on Climate Change

LEO: Low Earth Orbit

MBIE: Ministry of Business, Innovation and Employment

MOU: Memorandum of Understanding

NZSA: New Zealand Space Agency

R&D: Research and Development

SPAC: Special Purpose Acquisition Company

STEM: Science, Technology, Engineering, and Mathematics

VC: Venture Capitalist

### **1. Motivation for a Sustainable Future**

We are at an inflection point in history. After decades of the space industry developing at a steady but seemingly linear pace, dominated by agencies of nation states and big aerospace companies, the era of “New Space” emerged within the past ten years. With companies like SpaceX and satellite company Planet taking over dominant roles in launch capabilities and Earth observation services, the era of commercial space has finally been established.

The broader space industry is more than spacecraft, launch capabilities, and big budget missions, but is an extension of terrestrial industries in extreme environments. Furthermore, it is no longer viewed as just for science and research, but as a means to address global problems like monitoring climate change and a means for

more efficient food production for an expanding global population. Today, the space industry and associated technologies has been proving its critical role in solving challenges at a planetary scale. The recent IPCC report refers to satellite data more than 500 times as establishing the physical basis for climate change [1]. While we focus on the short and midterm applications for planetary sustainability, the Earth is currently the only known habitable planet in the solar system with finite space and resources. For humanity's long-term sustainability, it is imperative that we adapt and migrate outward into the solar system for resources and settlement for future generations.

There are abundant resources in the solar system for long term sustainability. Renewable energy, water and mineral resources, as well as infinite space to expand and thrive. Our goal as a species is to develop the technology and the aspiration to get there. Unfortunately, the technological divide between space-faring nations and the rest of the world is increasing. Today, there are now over 1727 space companies funded by different financial stakeholders [2]. While this positive trend is encouraging, these are mostly dominated by U.S. and European companies from space-faring nations. Government space budgets in 2021 from 90 countries total more than \$92B, but over 93 percent are from eight major space-faring nations [3]. Without active intervention, we run into creating a dystopian future where the rest of the world is left behind. To ensure the participation of the entire world, we need to build a global entrepreneurial space economy where everyone can participate and benefit - giving opportunities for any nation state or private entity to contribute and benefit.

In 2017, we incorporated SpaceBase Limited in New Zealand under the Edmund Hillary Fellowship programme [4, 5]. SpaceBase is a not-for-profit company with a purpose driven constitution. SpaceBase's mission and vision is that by helping educate, innovate, and catalyze space entrepreneurial ecosystems in emerging and developing countries, we can reduce the gap in space opportunities with developed countries. We begin by prototyping on best methodologies through bottom-up grassroots initiatives, to influencing top-down decision making on a national and local level within New Zealand. This paper outlines the 21 methodologies and our findings over the past five years. Our goal and intention are to share best practices to the rest of the world, and thus catalyze similar efforts in other nations.

## **2. Elements of a Space Ecosystem**

After several decades of participating in New Space efforts in the U.S. and observing space-faring nations grow their commercial space activities, we have

identified certain elements critical to catalyzing space ecosystems in emerging and developing countries.

### *2.1 Political Will and a Progressive Government*

Countries that have established national agencies or space offices have accelerated their ecosystem growth. This is further enhanced when coupled with funding sources in the form of grants, competitions, and the establishment of government backed institutions and research labs. Creation of tax incentives for the sector is also another initiative used to encourage growth in the sector. Regulations that are responsive to the needs of private space activities offer another advantage.

### *2.2 Existing Academic Ecosystems*

To accelerate capacity building and develop the foundation for the talent pool and future space workforce in a country, academic programs and degrees in aerospace engineering, satellite applications, and space related programs are critical to establish. Programs within the country can help prevent the brain drain of students needing to study abroad, with the possibility of not returning as they find opportunities in the space sector around the world.

### *2.3 Entrepreneurial Ecosystems*

For decades the global space industry was dominated by government activities and big aerospace companies. With the advent of accelerating and off-the-shelf technologies, new startup companies have emerged in the space sector creating a global entrepreneurial commercial space ecosystem. Certain locations, modeled on Silicon Valley, provide strong entrepreneurial support from incubators and accelerators. These environments, coupled with existing Angel and investor sources have increased the number of startups worldwide.

### *2.4 Funding Opportunities*

Early-stage funding sources from government and the private sector significantly increase the odds of success for entrepreneurial space startups. We discussed government funding sources above which help entrepreneurs get started with new concepts and enterprises without equity loss. A thriving Angel investor community and an established venture capital ecosystem, which are open to more long-term returns, are critical for space ventures to succeed.

### *2.5 Existing Space Infrastructure Capabilities*

Space-faring nations that have established launch capabilities have advantages to contribute to the global space economy. Space launch operations that come with the establishment of research and development facilities and manufacturing facilities have often enabled the growth of space sectors within that region. This is true in the case of NASA centers that support their surrounding

local economies or the existence of spaceports within a region.

### *2.6 Location*

Some locations are more conducive for launch facilities and spaceports. Countries near the equator are best for launching satellites into geostationary orbit, others at higher latitudes are better for Earth observation satellites launching into polar orbits. With the increase in air traffic around the globe, it is rarer still to find locations with east facing, open water launch sites that are away from major air traffic routes. Countries satisfying these parameters are good spots for establishing launch facilities. As reusable launch vehicles demonstrate greater reliability, then launch sites away from the coast may become more routine.

### *2.7 Culture of Risk*

By its nature, the space industry is a risky business. The space industry is normally capital intensive, particularly on the upstream or manufacturing side. Return on investment for space projects can take much longer than other industries to realize. It takes an inherent culture of embracing risk to participate in this industry. More traditional or risk-adverse societies based on well established, tried and tested activities normally do not fare well in such an environment. Countries with an established entrepreneurial ecosystem accelerate development of the ecosystem faster.

### *2.8 High Tech Ecosystem*

The presence of already existing high technology industries (e.g., digital manufacturing, computing, AI and robotics, and composite industries) are the building blocks of creating a thriving space industry. The existence of high-tech adjacent industries such as aircraft and automobile manufacturing, or data analysis and computing facilities, are just one step removed from creating products and services that cater to the space industry.

### *2.9 Industry Partnerships*

Collaboration between existing adjacent industries to support space activities in the form of industry associations and clusters help further accelerate formation of startups and provide facilities for development and testing. Membership dues and sponsorships to provide in-kind support, and other services such as incubators, accelerators, and co-working spaces enable nascent ecosystems to grow. Encouraging industry and academic partnerships as well as public-private collaborations all help leverage existing facilities and expertise for new technology advancement. Countries like Luxembourg, Singapore, Japan, and Australia are leveraging new aerospace consortiums that focus specifically on space market segments [6].

### *2.10 International Cooperation*

Countries collaborating on research development and space projects have established programs where less developed space nations learn from more established ones. Engineers and scientists sent to space research institutions for academic training give the opportunity for technology transfer and knowledge sharing. This can lead to mission collaboration at the onset, followed by local manufacturing and operations once a critical mass of specialists return to start their own initiatives. Partnerships between nation states and memberships in international organizations such as the United Nations, as well as endorsement of international policies and regulations, give opportunity for emerging countries to develop their expertise within joint initiatives, leading to solo projects in the future.

## **3. Space Industry Trends and Opportunities**

The space industry has started to accelerate development in the past decade. While the prior 50 years was represented by a linear growth in technological advancements in the space sector, increase in New Space activities and commercialization of missions and initiatives are now the norm. The global space economy is currently \$386B and growing, with over 72 percent in the commercial sector [7].

Today, there is a dramatic increase in startup companies worldwide. Once predominantly US based, startups now come from all over the globe. Thirty percent of space startups are from China and five percent each for Singapore and the United Kingdom [8]. Likewise, investment in the space sector is on the rise. Growing from a small amount in 2010 to a total of \$264B in total investments between 2013-2022 [9]. These increases in investments have not slowed down during COVID and have even diversified from Angels and VCs to more traditional debt financing from banks and new funding mechanisms like SPACs [10]. A trend towards the creation of space focused funds to accelerators is also on the rise for every region.

This dramatic growth in the global space industry was brought about by exponentially accelerating technologies such as computing and AI, robotics, and digital manufacturing. The proliferation of new technologies has allowed the miniaturization of satellites and components, leading to lower costs for both upstream and downstream markets. This coupled with the validation that off the shelf technologies like computers and cell phone sensors and parts that can work in space rather than rigorously developed space components and parts has further demonetized the industry. The increase in available launch opportunities brought about by different business models like hosted payloads and ride share opportunities from SpaceX, and small dedicated launchers like Rocket

Lab has further decreased the cost of missions and spacecraft globally [11].

In the downstream sector, technology advances in computing and machine learning, and the trend towards open source and free access to satellite data and software has also further opened opportunities for startup companies to create products and services from data analysis to satellite remote sensing applications [12].

New policies created by progressive governments have allowed agile and quick decision making, cutting the typical 18-month mission cycle into months and days as proven by missions launched for Fleet Aerospace and Astrix Astronautics in recent years [13, 14].

The opportunities for adjacent industries have increased leveraging already existing technologies applied to the space sector. Industries like agriculture, telecom, IoT, and precision engineering and manufacturing are beginning to participate in the space sector through existing capabilities.

#### **4. How New Zealand space industry has changed**

The following section describes NZ space industry changes over the past five years based on elements of a space ecosystem described above.

##### *4.1 Political Will and a Progressive Government*

In New Zealand, a progressive government established the New Zealand Space Agency (NZSA) in 2016 not for government sponsored missions but as an effort to enable commercial activities including Rocket Lab launch operations. The establishment of policies such as the *Outer Space and High Altitude Activities Act 2017* has created the means for progressive and sustainable outer space activities to take place, and help foster growth in the sector [15]. Today NZSA is working on a national aerospace strategy, soliciting multi-stakeholder insight and expertise from all sectors.

##### *4.2 Existing Academic Ecosystems*

While previously lacking space focused educational programs in the country, three top universities in Auckland, Christchurch, and Wellington have now started offering variants of aerospace and space science courses for undergraduate and graduate level degrees. University of Auckland has aggressively established an Auckland Space Institute, establishing the teaching core and research and hardware testing labs needed to attract students in this field [16].

##### *4.3 Entrepreneurial Ecosystems*

New Zealand in general has a thriving entrepreneurial ecosystem in each major city. Today, while there are no dedicated space incubators that exist in the country,

incubators like Outset Ventures, University of Canterbury Centre for Entrepreneurship, and Ministry of Awesome are beginning to support space focused startups in their cohorts [17, 18, 19].

##### *4.4 Funding opportunities*

The space agency in New Zealand has not allocated significant funding for space projects and initiatives beyond a partnership for MethaneSAT. There are small funding grants from Callaghan Innovation and the Catalyst Fund in place to help pre-seed entrepreneurs to get off the ground with their ideas [20, 21]. Moreover, traditional VC firms are starting to support space startup companies on their Seed and Series A rounds. In addition, space focused national competitions such as those delivered by SpaceBase help seed resources and mentorship to those who choose to participate.

##### *4.5 Existing Space Infrastructure Capabilities*

In New Zealand, the presence of Rocket Lab operations has brought the demand for space related jobs to the country. As described in a 2019 article, there are approximately 1000 Rocket Lab suppliers from engineering and manufacturing vendors from within the country, which make up a significant part of the NZ space industry [22]. Likewise, ground stations in the South Island have birthed a niche industry supporting deep space and LEO missions through communications for both government and private sector space assets around the world. The recent establishment of SpaceOpsNZ validates this demand [23]. Lastly, current needs for space situational awareness for the growing satellite industry as well as space debris mitigation and monitoring has put a spotlight on private company LeoLabs which has a satellite tracking radar based in the South Island of New Zealand [24].

##### *4.6 Location*

New Zealand, an isolated island at the bottom of the southern hemisphere, has the great location for launching polar satellites. Situated on the east coast of the North Island with less trafficked air space, the Mahia peninsula launch complex for Rocket Lab is a great location for a thriving spaceport. Today, Project Tawhaki in the South Island, a new testing area for aerospace activities, aspires to be NZ's second commercial spaceport [25].

##### *4.7 Culture of Risk*

New Zealand is known as a nation of explorers. Its culture is based on Polynesian migration across the Pacific to unknown territories, with Maori finally reaching New Zealand in the 14th century. In a 1983 conference, the Polynesian migration was deemed the best analog for space exploration and migration into the solar system [26]. Coupled with New Zealand's "Number 8 wire" mentality - described as a 'MacGyver-like'

mindset - this combination of innovation and ingenuity brought about by isolated self-dependency is the perfect culture for embracing a risky space industry.

#### 4.8 High Tech Ecosystem

New Zealand has a strong manufacturing base, in particular in Christchurch and Auckland, which already support the nascent space industry. University R&D facilities have been leveraged to develop technologies, such as propulsion and agritech, in adjacent industries which are already thriving in the country. Niche space components are being produced in NZ for a global market. Dozens of space enabled companies exist, including GPS and IoT enabled products and services. The 2019 Deloitte report on New Zealand's space economy gives a breakdown of the different contributing industries to the overall NZ\$1.7B high tech space industry [27].

#### 4.9 Industry Partnerships

The formation of the Aerospace Christchurch four years ago and the newly formed Aerospace Auckland has rallied the wider aerospace community [28]. Creating a forum of meetups, networking, and mentorship events all contribute to growing the ecosystem, and gives individuals and companies an industry forum for opportunities to collaborate. An overall national industry association (which included adjacent industries) that could support funding needs for the entrepreneurial ecosystem has yet to be established.

#### 4.10 International Cooperation

New Zealand joined the UN Committee on the Peaceful Uses of Outer Space (COPUOS) in 2016. It signed the Artemis Accords in May 2021, an important milestone in regulating lunar activities as humanity returns to the Moon with NASA's Artemis program. NZ has also signed several collaborative agreements with the US and countries such as Australia and Germany, as well as the European Space Agency. It has partnered on joint missions such as MethaneSAT with academic institutions in the US [29]. Most recently, it signed a partnership with company Axiom, opening up opportunities for scientific payload experimentation on commercial space stations scheduled for operations in the next 2-3 years [30].

While we focus on how New Zealand fares in accordance with above ecosystem elements, table 4 gives a summary of how other countries have been assessed, based on workshops conducted with participants from these countries.

### 5. What SpaceBase has done in New Zealand

Over the past five years, SpaceBase has attempted to catalyze the growth of the New Zealand space

ecosystem. We have tested more than 20 different initiatives, including ones to influence multi-stakeholder decision makers in government, academia, industry, and financial institutions. The following are the different methodologies we have used in three categories.

#### 5.1 Education and Outreach

While space is increasingly becoming mainstream, a huge barrier for growing the industry is in the fundamental perception of the role of space in society. We feel that space is a vital element of addressing global problems and important for the future of humanity. A huge part of ecosystem building is to create a mind shift in the eyes of the public and highlight the role of space in addressing problems that concern the general population. This can only be achieved through education of the public and the different stakeholders to gain support and funding. SpaceBase used the following toolkits:

##### 5.1.1 Speaker Series

Creating opportunities for talks, panels, or webinars using already established and related events such as the International World Space Week in October, Yuri's Night in April, or International Moon Day in July. Leveraging existing local venues such as co-working spaces or existing Meetup groups to reach different adjacent communities and the public. During COVID, many of these events moved to online forums. But the discussions and networking are an important element of these events.

##### 5.1.2 Written Articles

We used opportunities to write articles, opinion pieces, and submitting papers and posters to international space conferences to increase visibility and understanding of the current space industry opportunities and benefits.

##### 5.1.3 Newsletters

Leveraging SpaceBase's accumulated network database of a thousand interested individuals and organizations to periodically update and inform interested communities on space activities and initiatives.

##### 5.1.4 Briefings

We seek out opportunities to educate new community stakeholders from financial institutions, investor groups, to adjacent industry decision makers. These could be in the form of online presentations or in-person briefs.

##### 5.1.5 Teaching

We maintain our teaching affiliations with space organizations such as the International Space University, Frontier Development Lab, and Singularity University to share lessons learned on ecosystem building while

promoting New Zealand space activities to the rest of the world.

#### *5.1.6 STEM Activities*

As time allows, we participated in local science and space events such as the annual NZ TechWeek, and Engineering Days, as well as festivals, creating opportunities to conduct “Space Days” at schools. We developed interactive activities for primary school to panel sessions for secondary and university levels.

#### *5.1.7 Workshops*

We developed a specific “Catalyze a Space Industry in Your Region” workshop that can be delivered interactively online and in person. More information on this in Section 6. A free asynchronous version of the workshop is also available on the Thinkific platform [31].

#### *5.1.8 Podcast*

SpaceBase puts out a monthly space podcast which features the careers of Kiwi or affiliated individuals working in the space industry. Describing how different individuals started working in space highlights the wide variety of space career paths and opportunities no matter what field of study you specialize in.

#### *5.1.9 Radio and Print Interviews*

Participating in periodic national radio shows and granting podcast interviews to help educate the public on space activities and topics of current interest in space happening locally and globally.

### *5.2 Entrepreneurship and Innovation*

To accelerate capacity building and talent development in the local space ecosystem, entrepreneurship and innovation activities are strategically conducted to catalyze projects and start-ups in the local regions. For New Zealand, a combination of a culture of entrepreneurship and ‘Number 8 wire’ mentality accelerates innovation further.

#### *5.2.1 Challenge Competitions*

Leveraging incentive prizes on a national, and later Pacific regional level has birthed research projects and startups in New Zealand. SpaceBase has run three national and regional competitions awarding prize winners up to NZ\$40,000 in cash, data, and mentorship opportunities. The challenges are offered to students and startups to focus on a local problem that can be addressed through space technologies. These competitions have also been an effective opportunity to brief the public on the benefits of leveraging space technology to solve grand challenges. The challenges have catalyzed collaboration of local regional development organizations to support challenge teams within their region and incentivize existing incubators to support

them. Our 2021 challenge “Space for Planet Earth” in partnership with satellite company Planet awarded both high school and university students on satellite-based solutions for coral health and carbon sequestration aspects of climate change [32, 33].

#### *5.2.2 Online Incubator*

As part of the Challenge competition, SpaceBase has also run the first online space research incubators in New Zealand - supporting the challenge teams in their efforts to finalize their final application solutions. The objective is to accelerate the process of research and development to come up with a product or solution for the competition. This includes sessions on satellite remote sensing and analysis, and entrepreneurship sessions covering design thinking, product market fit, and rapid prototyping. Sessions on how to give a successful pitch presentation and coaching sessions are included.

#### *5.2.3 Startup Mentorship*

Over the past five years, SpaceBase has advised and mentored 34 entrepreneurs and startups in New Zealand and abroad pro-bono. These include opening up our global networks for introductions and further advice from experts in specific space industry fields, to specific feedback and recommended improvements on existing products and services that would appeal to current opportunities and trends globally and locally.

#### *5.2.4 Technical Due Diligence*

With diversification of funding sources for space startups on the rise, Venture Capital (VC) firms are increasingly looking at space as investment opportunities. For the past year SpaceBase has also offered services for technical due diligence to local VCs funding Seed and Series A rounds for space startup companies in New Zealand. Our wide breadth of expertise in technical areas and industry trends has allowed us to objectively assess and validate the feasibility of new upcoming technologies for the industry.

#### *5.2.5 Partnership Matching*

Recently SpaceBase has started facilitating potential collaboration opportunities between space companies and startups with niche expertise through brainstorming sessions over specific industry challenges. These sessions could foster potential partnerships for future projects and market opportunities.

#### *5.2.6 Business Attraction*

SpaceBase has also engaged with local economic development agencies, helping do further market research on potential business opportunities abroad and representing local areas to attract foreign based companies to look at New Zealand as a new investment and business opportunity.

### 5.3 Community Building and Collaboration

While SpaceBase continues to run educational and entrepreneurial initiatives, limited resources make it imperative to establish local collaborations and create partnerships, leveraging existing networks and organizations with the connections, resources, and influence to grow the space ecosystem in New Zealand. Collaborations with local and national government to industry and financial institutions have been effective at creating the critical mass to start projects, influence strategy, and give decision makers the incentive to consider the space industry for national economic development.

#### 5.3.1 Meetup Creation

The first initiative SpaceBase did was to create a local space Meetup group to catalyze interest and recruit volunteers in Wellington. This proved to be the easiest to set up, leveraging free venue opportunities from local sites and collaboration with interested organizations. During the pandemic, meetups were largely online. SpaceBase was also a supporter or member of subsequent meetup groups and associations such as Aerospace Christchurch and Aerospace Auckland.

#### 5.3.2 Market Research and Directory

The second initiative SpaceBase did was to conduct market research to understand where the aerospace

organizations and industries were located within New Zealand. We created a classification system for each subsector of the industry. This directory is maintained and searchable on the SpaceBase website. Today there are 253 space related companies and organizations in New Zealand in the SpaceBase directory (figure 1, table 1). In 2019, the database became the baseline for the MBIE Deloitte economic study citing NZ\$1.69B annual contribution of the space industry to the New Zealand economy [34].

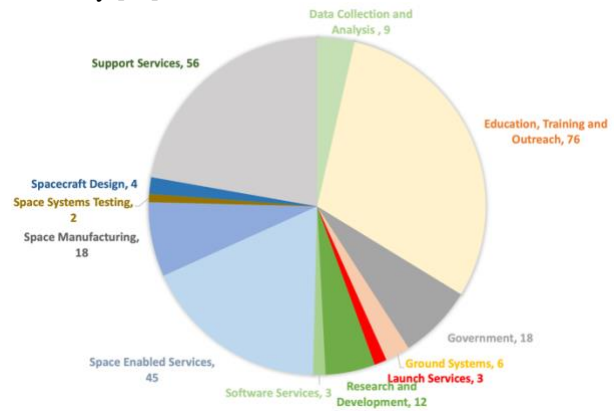


Figure 1. Space Industry Distribution in New Zealand from the SpaceBase Directory

Table 1. Space Industry Distribution by New Zealand Location

Industry Category	Auckland	Christchurch	Wellington	Other	Total
Data Collection and Analysis	1	5		3	9
Education, Training, and Outreach	17	8	11	40	76
Government	2	3	11	3	18
Ground Systems		2	1	3	6
Launch Services	1	1		1	3
Research and Development	3	2	4	3	12
Software Services	2	1			3
Space Enabled Services	10	9	8	18	45
Space Manufacturing	6	10	1	1	18
Space Systems Testing	1	1		1	3
Spacecraft Design	3	1			4
Support Services	19	14	15	8	56

#### 5.3.3 Website Networking Platform

As part of the SpaceBase website, we created a space industry platform integrating the searchable database to a registration-based network platform for space focused individuals. This platform allows individuals working in the space industry to create their own profile pages and is also searchable. The platform was also leveraged during the first two space and aerospace challenges SpaceBase delivered as the online forum and resource repository. While the platform is largely dormant, it has been emulated by other space ecosystems in other regions of the world [35].

#### 5.3.4 Social Media Promotion

To keep the general public informed of up-to-date space events and information, SpaceBase maintains social media channels on Facebook, Twitter, LinkedIn and Instagram, allowing the space ecosystem an online voice and presence to share information while growing the community base [36].

#### 5.3.5 Student and Association Creation

SpaceBase was instrumental in catalyzing the student space association in New Zealand which to date has two chapters in Wellington and Christchurch and has been an

early supporter of the Women in Space Aotearoa New Zealand association [37, 38].

*5.3.6 Government and Industry Advisement*

A rapid way to catalyze a space ecosystem and influence economic development growth is through development of technology strategies and space road maps on a national and local level. As an example, our collaboration and advice with the local Christchurch economic development agency has contributed to Christchurch’s 2019 Aerospace Sector Plan naming

aerospace as one of their technology supernodes [39]. Since our incorporation, we have also been involved in three NZ Space Agency brainstorming sessions and have submitted proposals and feedback on its current draft aerospace roadmap. It is our intent to support the theme of “sustainable space” development in the coming years.

Table 2 summarizes the SpaceBase efforts and results over the past five years within the three categories.

Table 2. SpaceBase Impact Highlights (2017 - 2022)

Education and Outreach	Entrepreneurship and Innovation	Community Building and Collaboration
70 presentations 33 briefings 37 speaker series as Meetup events 37 interviews and articles 46 training and workshop sessions 16 expo & conference activities 16 projects, including challenges and virtual incubator 43 podcast episodes	34 startups/entrepreneurs and organizations mentored and advised 3 challenges operated and judged 119 potential Challenge teams/solutions over three competitions generated 132 incubator participants from 30 teams facilitated 9 startups catalyzed 22 incubators engaged 5 space startups obtaining seed funding through tech due diligence and intros	17 space initiatives collaborated 1 space Meetup group created 2 space social media platforms created 6 national/local strategy workshops and proposals participated 145 partner organizations and collaborators 14 regional Economic Development Agencies engaged 18 universities, colleges schools engaged

*5.4 Evaluating Effectiveness of the Toolkits*

The first five years of SpaceBase can be attributed to a prototyping process using the various toolkits described above to understand methods that will yield the best and largest impact results. In table 3 we have ranked each toolkit according to effort and effectiveness. A rating scale between 1 and 3 is assigned, 3 yielding the most effort and impact respectively. We have also indicated whether space expertise was needed to deliver the toolkit for category.

Results of the ranking exercise show that there are methods that need very little effort to yield a significant impact to ecosystem building. Examples include creating Meetup groups in cities or regions or creating social media channels to grow a space community. This encouraging conclusion gives further justification for individuals to initiate ecosystem building, even with very little experience in the industry or have minimal resources.



Table 3. Toolkit Analysis

Toolkit	Method	Effort	Effectiveness	Expertise
Education and Outreach	Speaker Series	1	1	If presenting
Education and Outreach	Written Articles	2	1	yes
Education and Outreach	Newsletters	2	2	
Education and Outreach	Briefings	1	2.5	yes
Education and Outreach	Teaching	2	2	yes
Education and Outreach	STEM Activities	2	1	yes
Education and Outreach	Workshops	2	2.5	yes
Education and Outreach	Podcast	2	1	
Education and Outreach	Radio and Print Interviews	1	1	yes
Entrepreneurship and Innovation	Challenge Competitions	3	3	
Entrepreneurship and Innovation	Online Incubator	3	3	
Entrepreneurship and Innovation	Startup Mentoring	2	3	yes
Entrepreneurship and Innovation	Technical Due Diligence	3	3	yes
Entrepreneurship and Innovation	Partnership Matching	1	2.5	yes
Entrepreneurship and Innovation	Business Attraction	2	2	yes
Community Building	Meetup Creation	1	2.5	
Community Building	Market Research and Directory	3	3	
Community Building	Website Networking Platform	3	1	
Community Building	Social Media Promotion	1	3	
Community Building	Student and Association Creation	2	3	
Community Building	Govt and Industry Advisement	1.5	3	yes

**Legend:**

Effort

- 1 - Minimum time, preparation, and resources
- 2 - Moderate time and preparation, some resources and funding needed
- 3 - Extensive time and preparation, or large funding needed to execute

Effectiveness

- 1 - Minimal impact on creating ecosystem
- 2 - Moderate impact on ecosystem, leading to other avenues of growth
- 3 - Significant impact on ecosystem building with multiple initiatives generated

**6. Scaling SpaceBase Impact Globally**

As part of our suite of toolkits, we have specifically developed an online and in person workshop targeted to directly accelerate local space industry growth. The workshop is focused on multi-stakeholder decision makers in government, academia, industry and financial sectors. Individuals who can make the necessary policy, regulatory, and strategic changes to increase growth in this sector are the ideal target audience.

The workshop objectives include a) learning about trends and market opportunities in the New Space industry; b) know how to assess local and national space industry capabilities; c) identify needs and requirements on how to grow a space industry locally; d) identify opportunities and pathways to participate in a local space economy; and e) identify actionable first steps.

The first part of the workshop includes a summary of current space industry opportunities and trends delivered by SpaceBase. Participants are then gathered into small groups where they work together through several

assessment sessions to understand local or company capabilities, needs, challenges, and opportunities. The goal of the workshop is to come away with actionable initiatives that are immediately implementable. SpaceBase consulting services can further advise and assess needs for creating a strategic plan of action customized to a specific local area or organization.

The workshop can be delivered interactively through video webinar or in workshop format in person. A free asynchronous version of the workshop is available via the SpaceBase website [40].

*6.1 Workshop Format*

*6.1.1 Capabilities Assessment*

This section of the workshop gives the participants time to do a quick market research on the local area in focus. Identifying existing space activities and capabilities for both upstream and downstream industries. Participants are asked to assess the competitive advantages of the country, region, or city through government programs, location suitability, existing

infrastructure, funding opportunities, and educational programs. Assessing whether a culture of entrepreneurship exists is also an important factor for success.

### 6.1.2 Opportunities and Needs Identification

The bulk of the workshop is spent on understanding the local areas' strengths and weaknesses as well as opportunities and strengths. Understanding the challenges in terms of political, economic, social, technological, legal, and environmental factors that could influence and affect the success of building a space ecosystem are identified and discussed. Lastly, based on these factors, identifying the needs for success in each of these areas is also discussed and identified.

### 6.1.3 Actionable Strategic Plan

The last and most important exercise is the identification of a suitable market or sub industry based on the capabilities and assessment exercises. Understanding the needs for the chosen industry to flourish is an important step before identifying specific actions to be carried out by the participants themselves.

## 7. Ideas and reactions from workshops

To date, we have run the *Catalyzing a Space Industry Locally* workshop both online and in person eleven times over the past two years with participants coming from

over 40 countries. The majority of the workshops were delivered at multiple International Space University executive and space studies programs as part of the business and management departments, in person and online. Participants range from professionals in different space disciplines already working in the industry, to executives planning on a career change in space.

We have also conducted several of the workshops targeted to specific areas in New Zealand such as Christchurch and Northlands. These sessions were proven very insightful and effective when participants come from multi-stakeholder sectors giving a 360-degree perspective and insight on challenges and opportunities within a local area.

Leveraging the eleven workshops conducted, Table 4 summarizes the strengths, weaknesses and needs for each of the 23 countries assessed by workshop participants to date. Using the identified sustainability elements for a space ecosystem, we have also identified the elements existing for each country based on the summary assessment. In the table, we can see how space-faring nations have consistently cultivated the elements needed for the ecosystem to thrive. Keep in mind that these were initial assessments of these countries by the participants in these workshops.

Table 4. Space Ecosystem Elements by Country based on Workshop Assessment

Country	Political Will/Govt Support	Location	Existing Infrastructure	Entrepreneurship	Existing Academic Programs	Funding	High Tech	Culture of Risk	Established Industry Partnerships	International Cooperation
United States	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
United Kingdom	✓		✓	✓	✓	✓	✓		✓	✓
Switzerland			✓	✓	✓	✓	✓			✓
Sweden	✓		✓	✓	✓	✓	✓			✓
Slovakia					✓		✓			
Portugal	✓	✓	✓	✓	✓		✓			✓
Nigeria				✓						

Table 4. Space Ecosystem Elements by Country based on Workshop Assessment (continued)

Country	Political Will/Govt Support	Location	Existing Infrastructure	Entrepreneurship	Existing Academic Programs	Funding	High Tech	Culture of Risk	Established Industry Partnerships	International Cooperation
New Zealand	✓	✓	✓	✓	✓	✓	✓	✓		✓
Netherlands	✓		✓	✓	✓		✓		✓	✓
Malaysia			✓			✓				
Luxembourg	✓			✓	✓	✓	✓		✓	✓
Kenya					✓		✓			✓
Japan	✓	✓	✓	✓	✓	✓	✓		✓	✓
Italy			✓		✓	✓	✓			✓
Israel	✓		✓	✓		✓	✓	✓		✓
Ireland	✓			✓	✓		✓		✓	✓
India	✓	✓	✓		✓		✓			✓
France	✓	✓	✓		✓	✓	✓			✓
Costa Rica		✓								
China	✓	✓	✓	✓	✓	✓	✓		✓	✓
Canada	✓		✓	✓	✓	✓	✓			✓
Brazil	✓		✓							✓
Austria					✓	✓	✓		✓	✓

We also cross checked the listed Action Plans submitted by workshop participants against SpaceBase toolkits (table 5). This was a validation of the majority of toolkit methods we have implemented along with other initiatives recommended for each specific country or region.

It is our intention to run the workshops for each economic development region in New Zealand pending funding resources. The long-term intent is to partner with

international organizations such as the United Nations and other ecosystem focused organizations, with existing international connections. Specifically focusing on emerging and developing nations to share this assessment tool. We believe the workshop can accelerate a local area's understanding of their strengths and opportunities when it comes to creating a strategic plan for growing or catalyzing a space industry in their local country, region, or city.

Table 5. Action Plan Workshop Validation

Action Plan Initiatives	
Market Research	✓
Finding Investors	✓
Space Program degrees and Courses	✓
Govt Support for facilities and labs	✓
National Space Policy	
STEM Education	✓
Create Industry-Academia Partnership	
Funding Mechanisms / Space Fund	✓
Learn from other Countries	
Public Awareness and Outreach	✓
Incubators	✓
Workshops	
Internships	
Create a National Lab/Research Institute	✓
Career Talks and Network Opportunities	✓
Briefings for Decision Makers	
Govt Initiatives for attracting space talent	
Online Resource Platform	
Establish a National Space Office (for those without agencies)	

✓ : Multiple mentions

## 8. Conclusion

SpaceBase will continue to catalyze an entrepreneurial space ecosystem in New Zealand using the toolkits we have prototyped and implemented. Initial impact results of the methodologies implemented can be qualified through the development of the ecosystem in the past five years. The elements needed for an entrepreneurial ecosystem to thrive is also consistent with the elements present in successful space-faring nations to date and can serve as a benchmark for evaluating progress within a country, city, or region. It is our intent to create an objective rating system for benchmarking space ecosystem building in the future and serves as the next step towards SpaceBase goals of sharing best methodologies for emerging and developing countries to leverage for the future.

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