NEW ZEALAND: A SPACEFARING NATION

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Outer Space and High-altitude Activities Act 2017

Public Act 2017 No 29
Date of assent 10 July 2017
Commencement see section 2

Approved by the New Zealand Parliament on 10 July 2017, the above act will come into effect on 21 December 2017. An initiative led by the private sector, it is significant landmark, launching New Zealand into the league of spacefaring nations.

1. Legislative Framework of New Zealand-based Space Exploration Activities

New Zealand is already a party to the Outer Space Treaty, Rescue Agreement and Liability Convention but in the absence of any spacefaring activities, New Zealand has not had the need to give effect to them through a national space law. The government's decision to permit Rocket Lab to undertake space launches from New Zealand territory has required it to give effect to the international treaties it is signatory to through a suitable national legal framework. It has also had to re-consider its position vis-a-via other international treaties/laws/regulations.

The new law, Outer Space and High-Altitude Activities Act (OSHA Act), is intended to establish a licencing regime to regulate all the activities related to:

a) Space and payload launches from New Zealand or by New Zealand nationals overseas,
b) Launch facilities in New Zealand, and
c) High altitude activities that originate from New Zealand

In addition to the OSHA Act which lies at its heart, the legal framework being established by the Ministry of Business Innovation and Employment (MBIE) intends to accede to the Registration Conventions and the Moon Treaty as well as a Technology Safeguard Agreement (TSA) with the US government to protect sensitive technology being made available to Rocket Lab from the US.

The unique feature of the OSHA Act is that although it is generally in line with international best practice, New Zealand will be the first country in the world to develop a customised regulatory regime for high altitude activities (HAVs). These will require bundled licences that will cover the launch vehicle and payload. It will not apply to aircraft or high altitude balloons and drones, which are managed under existing civil aviation procedure. HAVs are conducted from the operating altitudes of aircraft, at around 18 km above sea level, to the Karmen line at 100km where outer space is deemed to begin. It should be noted that as international space treaties do not apply to HAVs, the OSHA Act does not apply to New Zealand nationals undertaking HAVs outside of New Zealand

The OSHA Act comprises of regulations for both local and overseas (New Zealand national-initiated) launch licences, payload permits on a case-by-case basis and launch facility licences for up to 5 years.

Today's space laws, especially in the case of New Zealand, need to ensure that they do not stifle private sector innovation while endeavouring to minimise the diverse risks associated with spacefaring. This is the challenge that New Zealand is addressing through the OSHA Act, providing flexibility through a proportionate and risk-based decision framework where the regulatory requirement can be adjusted in response to the situation.

2. Economic and Ethical Considerations

2.1 Benefits

The economic value-add to the New Zealand economy from becoming a spacefaring nation has been quantified by the government's economic review commission at US$415 - $1,073 million over 20 years. While most of the benefits are likely to accrue to Rocket Lab community and a handful of their key New Zealand suppliers, the wider range of benefits include additional employment, construction and launch activities, space tourism, cluster effects (e.g. satellite manufacturing, carbon composite, 3D printing), knowledge and technology spill-overs, aspirations effects (motivating students, researchers and "garage inventors") and national prestige effects. Further upside potential exists from new companies choosing to operate from New Zealand and new, unforeseen opportunities brought by the other spacefaring nations looking for partners.

2.2 Costs

As this is a private sector-led initiative, the costs to government are limited to that of establishing the legislative framework under discussion and the licensing and monitoring operations of the fledgling space agency. These are not significant for a government which has a sunk cost of US$17 million supporting innovation by Rocket Lab in the past.

2.3 Risks

New Zealand basing its entry into spacefaring on the back of Rocket Lab's activities alone could be seen as a risk. Resulting in the evaporation of the forecast benefits, the lack of sufficiently successful operations by Rocket Lab would provide only a minor reputational risk. Meanwhile, the working partnership being developed with NASA and the potential to be a country with one of the highest shares of commercial space launches in the world, more than justifies it.

The OSHA Act does not define outer space. While the Australian legislation uses the Karmen line, there is no international consensus on this and New Zealand appears to be keeping in step with the international norm through its decision. Consequently, this is not seen as a risk of any significance.

There are however various risks associated with launches given launch failures are still a feature of the industry (6.1% of all launches fail, as discussed in 3.2.1 below). A key reason for the existence of various international treaties is to allocate responsibility from any damage arising from launches to the nation from where the launch takes place or for launches undertaken by its nationals anywhere in the world. The OSHA Act has been drafted specifically to regulate such space launches, payloads, New Zealand-based launch facilities and any high-altitude activities that originate from New Zealand.

The OSHA Act contains provisions for indemnifications and insurance, as is the case with the UK and Australian laws. The US, however, has set an upper limit on the amount of the indemnity on the launch or payload providers and accepts liability for anything over that. New Zealand has opted not to follow this approach as there is insufficient information at this stage of Rocket Lab's development and pioneering intension of high-frequency launches, so setting a cap would not be appropriate. Assessing the risks and setting the indemnity and/or insurance requirements for the launch or payload on a case-by-case basis is the OSHA Act's approach. This protects New Zealand's liability under its international treaties by passing it on to the launch and payload operators. The case-by-case approach provides a degree of flexibility to either mitigate the risks through suitable risk sharing with other nations involved or through the ability to make customised decisions on the specific risk-benefit dynamics of each case.

There are also risks associated with the nature and quality of the payloads being launched and the OSHA Act contains specific provisions to deal with these risks.

2.4 Ethics

New Zealand has a reputation as an influential, fair-minded and responsive global citizen. The commitment to give full effect to its international obligations and the embracing of the Moon Treaty, avoided by many spacefaring countries who wish to preserve their potential future positions, confirms New Zealand's good citizen approach within the international context. This, coupled with recent increased international profile from having been one of the five elected members in the UN Security Council, has helped position New Zealand as a spacefaring nation that could possibly act as an 'honest broker' in the event matters in outer space lead to disharmony between nations, especially in Asia.

Locally, New Zealand is committed to preserving a sustainable environment and although the impact on the atmosphere from the pollution resulting from rocket launches is insignificant in general, the government should monitor the situation in case it becomes a problem e.g. if Rocket Lab were to undertake launches every 72 hours in line with its licence.

3. Launch Services sector of the Global Space Economy

3.1 Commercial Space Economy

The commercial space economy consists of satellite services (e.g. consumer radio and broadband services), fixed satellite services (e.g. transponder agreements and managed network services), mobile satellite services (e.g. voice and data), earth observations services (e.g. optical and radar images to the government and open market), satellite manufacturing, commercial space launch services, ground equipment services and insurance services. This accounted for about $200-250 billion annual revenues in 2015.

3.2 The Launch Sector

3.2.1 Launches

Commercial launches accounted for about a third of all launches (Table 1 below) and $2.15 billion in revenues in 2015.

Table 1: Worldwide launches in 2015 (Source: FAA cited in Al-Ekabi et al 2017)

	Number of Launch Systems	Total		
Launchers	active in 2015	L:		
Russia	11			
United States	11			
China	7			
Europe	4			
India	3			
Japan	3			
-	-			

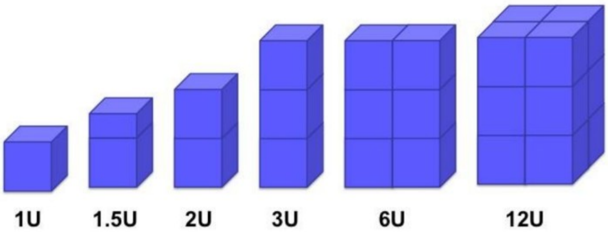
There were 4 launch failures (6.1% of all launches) in 2015, of which one was a commercial launch (4.5% of all commercial launches). This is a measure of the risks associated with launches - failures remain a part of this industry as it continues to innovate in order to reduce both the cost and the risk level of launches.

3.2.2 Payloads

The mission of the spacecraft determines the size of the payloads. NASA's classification based on payload mass are as follows:

- Femtosatellite 0.001 - 0.01 kg
- Picosatellite 0.01 – 1 kg
- Nanosatellite 1 – 10 kg
- Microsatellite 10 – 100 kg
- Minisatellite 100 -180 kg
- CubeSats: nanosatellites with a standard size and form factor that use 10x10x10 cm as one unit and are extendable to of 1.5, 2, 3, 6 or 12 units (Figure 1 below).

Figure 1: NASAWeb



There were 265 payloads launched in 2015 (Table 2 below) of which 143 (54%) were cube satellites with an average mass of 8.3 kg (micro payloads consist of science satellites, technological demonstrators or small communications satellites).

Table 2: Payloads launched in 2015 (Source: FAA and Gunter's Space Page cited in Al-Ekabi et al 2017

Payload by Mass Class	2015	Percentage	A	
Micro	78	29.4		
Micro (ISS releases)	65	24.5		
Small	41	15.5		
Medium	28	10.6		
Intermediate	10	3.8		
Large	42	15.8		
Heavy	1	0.4		

3.2.3 Orbits
The objectives of each mission will determine the spacecraft's orbit. The commercial launch orbits are:

- Low Earth orbit, **LEO**, at 100-600 miles altitude,
- Medium Earth orbit; **MEO**, at between 600 - 22,236 miles altitude
- Geosynchronous Earth, **GEO**, remaining continuously above the same longitude on Earth located at 22,236 miles altitude
- Geostationary orbit, **GSO**, which is a GEO directly above the equator and appears stationary from a point on Earth
- Highly elliptical orbits, **HEO**, with the perigee of around 660 miles and an apogee of about 24,000 miles per orbit
- **Polar orbit** which are LEOs whose revolutions passes over the North and South poles; and
- **Sun-synchronous orbit**, highly inclined orbits passing over the same point on Earth at the same time each day.

3.2.4 Rocket Lab's offering
The test launch conducted on 25 March 2017 marked the start of a spacefaring era for New Zealand. This event also marked a world first - with an orbital class rocket launched into orbit from a private launch facility. Although successful as a test, this launch did not reach orbit. Rocket Lab expects to reach orbit on one of the two remaining test launches. After that, Rocket Lab expects to launch around 4 to 5 times a month, subject to a satisfactory outcome of its planned test launches this year and continued demand for its services beyond the current forward orders.

Rocket Lab's Electron rocket is designed for a nominal payload of 150 kg to a 500 km sun-synchronous orbit, however it can be tailored for a range of circular or elliptical orbits at inclinations ranging from 39 to 98 degrees. Rocket Lab's Mahia Peninsula launch site offers attractive orbit choices – LEOs, HEOs, sun-synchronous, wide ranging launch angles including polar orbits.

Figures 2 and 3 below illustrate the additional flexibility available with Rocket Lab services in respect of choices over payload mass, altitude, circular orbit or elliptical orbits at different eccentricities.

Figure 2: Payload vs. Circular Sun-Sync Orbit Altitude (Source: RocketLabWeb3)

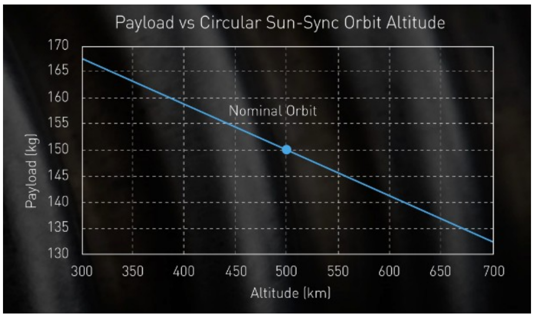
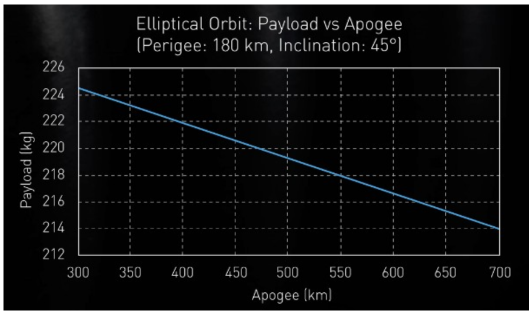


Figure 3: Eliptical Orbit Payload vs Apogee Perigee 180 km, 45^{o} inclination (Source:RocketLabWeb3



To increase the flexibility to its customers and to minimise delays, Rocket Lab has also developed a "plug-in payload" approach to its launches. This gives customers the choice of either Rocket Lab integrating the payload using the traditional process or passing responsibility to the customer. Customers would manage the payload process at their facilities and/or use their personnel and provide a sealed or environmentally controlled payload for integration with Rocket Lab's Electron. They also offer a "rideshare" option where different payloads are grouped and should be cost effective for those willing to share the launches.

Using an innovative design approach for its Electron rocket, the build time has fallen from months to days and with it the cost and affordability to customers. Meanwhile, innovations in avionics and guidance/navigation has further contributed to Rocket Lab's ability to offer high frequency launch schedules.

Rocket Lab's offering is to launch small satellites spanning a wide range of mission choices (with respect to orbits, payloads and process) cost effectively, within short lead-up times, as a result of the frequency of its launches.

Figure 4: Infographic of Electron (Source: Rocket Lab from KiwiSpaceWeb)

Figure 4 illustrates the competitive advantage offered by Rocket Lab via much faster wait time to launch (weeks vs. years) and the much cheaper costs (less than US$5 million vs US$133 million on average) which is very compelling. The cost of 1 Unit of CubeSat starts from a low U$50,000 bringing launching within the easy reach of many.

Customer numbers on Rocket Lab's forward orderbook for Electron launches are said to be in excess of 50 and include established/respected operators in the space industry viz. NASA, Spire, Moon Express and Planet Labs, while agreement with yet another high-quality customer, Spaceflight, was announced recently.

The small satellite sector is the fastest growing segment within the launch sector and, although there is currently a limit to launch capacity, it is positioned to become very competitive over the coming years.

Innovations in disruptive technology will continue to change the dynamics. For the present, however, Rocket Lab has a first mover advantage, estimated at 3 years, and remains well positioned to increase its market share within this segment as it builds its track record, experience and reputation as a reliable provider of timely, user-focused services.

From its privately owned New Zealand launch complex, Rocket Lab is focusing on a defined niche - circular or elliptical LEOs with a wide range of orbital angles including polar orbits and is targeting the fast-growing micro payload sector. Further, its Mahia Peninsula site is FAA compliant and according to Rocket Lab, can accommodate a launch rate of 120 flights per year while it is licensed for a launch to occur every 72 hours. This is a significant increase in potential launch capacity considering there were only 143 commercial launches of micro payloads worldwide in 2015 (see Table 2 above).

4. Analysing New Zealand's Approach to Spacefaring

New Zealand ranks No.1 in World Bank's "Ease of Doing Business Ranking". New Zealand has recognised Rocket Lab's intentions as a strategic opportunity for New Zealand to enter the fast growing and increasingly important space economy. It has put in place sufficient transitional legislation to facilitate Rocket Lab to undertake its launch activities while proceeding to establish a flexibly developed enabling legal framework to regulate Rocket Lab's activities and to attract participation from other space players in niche areas of the space economy where New Zealand has a comparative advantage.

Stemming from Rocket Lab's activities, New Zealand's current approach is to focus is on the launch sector of the space industry, an enabling rather than a primary space activity. Over the coming years, New Zealand-based space exploration activities have the potential to grow in significance based on the success of Rocket Lab.

4.1 New Zealand vs. Benchmark Spacefaring Countries

Space policy of each nation is unique and dictates its space law. Given the limited scope of New Zealand's approach, it is evaluated below against the following benchmark countries:

(i) **Australia** – an emerging space actor that has a close relationship with New Zealand due to their shared colonial heritage and geographic proximity

(ii) **India** – a second-generation space actor which (along with the emerging space power China) is a leading provider of competitively priced launch services within the region.

(iii) **South Korea** - going from no significant involvement in space activities to a second-generation space actor in about two decades and has launch sector involvement

(iv) **The USA** – the dominant first-generation space power, with a dominant position in the industry, especially in the commercial launch segment, whose national laws have been in place for the longest time, evolving to keep pace with industry progress.

4.2 Comparison of New Zealand to its Benchmark Spacefaring Countries

Though an OECD high income country and a top country for ease of doing business, New Zealand's economy is modest and its population small with 0.2% and 0.1% share of the world respectively. Table 3 illustrates New Zealand's relative insignificance by size but also its attractive private sector environment compared to the benchmark spacefaring nations.

Table 3: New Zealand vs. Benchmark Spacefaring Nations (Source: WorldbankWeb 1, 2 and 3)

	Population	Populati						
	Thousands	Rank						
New Zealand	4,596	123						
Australia	23,790	53						
India	1,311,051	2						
Republic of Korea	50,617	27						
United States	321,419	3						

Below, Table 4 compares space activities, regulatory infrastructure and space budgets.

Table 4: New Zealand vs. Benchmark Spacefaring Nations (Source: von der Dunk & Tronchetti 2015, Al-Ekabi et al. 2017)

	Activites in Space								
	Military	Civil	Scientific	(					
New Zealand									
Australia	Y	Y	Y						
India	Y	Y	Y						
Republic of Korea	Y	Y	Y						
United States	Y	Y	Y						

Table 4 shows:

- The niche nature of New Zealand's space activity
- The absence of a space agency in Australia – one of only two OECD countries without a space agency
- The absence of a national space law in India – although India is in its 6th decade of space activities, the government has been the sole operator and there is no reliable system to regulate any private sector suppliers to the industry
- The length (1958 space law) and commitment of US to space activities (with the highest space budget to GDP ratio and the largest space budget in the world which accounts for 25.6% of New Zealand's GDP!)

Other than the US, Russia and France, all other spacefaring nations' contribution to their respective space budgets is less than 0.5% of GDP but for New Zealand with a comparatively very low GDP base, reaching a space budget comparable to second-generation space players or even just Australia will be a massive stretch.

4.3 Discussion on New Zealand's Approach

Over 50 countries are engaged in the space economy in significant ways. New Zealand is a very late entrant into this economy. Its small size, vision of space as a luxury item in its national budget, non-military pursuit of its affairs and the preference of the space powers to partner neighbouring Australia were all contributing factors to this late entry.

The size of the space budget required to compete globally will be such a high portion of New Zealand's GDP that it will remain a luxury item for New Zealand given its comparatively low GDP base. As New Zealand's economic and human capital capacity is limited and it has no practical ability to fund space activities in the future, its private sector-led entry into the space industry makes perfect sense, especially given its top ranking on World Bank's ease of doing business measure.

Launching from New Zealand enjoys certain comparative advantages. Proximity to the ocean, low sea and air traffic and low population as well as its geographic location make it suitable for frequent and low risk launches at a range of launch angles. In addition, it has the following advantages for private sector operators:

- Globally competitive economy with exports accounting for 30% of GDP
- Business and innovation friendly environment with a skilled workforce
- Politically stable with an open political system and the least corrupt public sector in the world (Transparency International 2016 Corruption Perception Index

Comparing these advantages to the benchmark nations shows:

- Setting up a Space Agency and establishing a legal framework with an appropriate space law would offer a better environment for private sector space players than Australia which lacks a space agency and India which is yet to pass a national space law
- The export compliance, average wage and facility cost of doing business are lower in New Zealand compared to Australia and the US
- Although India is attractive as an English-speaking country with high quality personnel with space expertise and particularly low costs, ranked 150 for ease of doing business and the lack of national space law makes it a difficult environment for the private sector
- Korea is a nation for New Zealand to emulate with regard to what can be achieved with the right commitment and guidance from the government but also a country watch as it may pose a threat as a serious future competitor
- US is already partnering Rocket Lab and has signed the TSA with New Zealand and has much to offer by way of best practice and technical support

New Zealand's willingness to grasp this private-sector initiated opportunity and become a spacefaring nation is a strategic step that could, over time make a significant contribution to its economy and also its ongoing space actor status. New Zealand is laying a comprehensive foundation with the appropriate space law, legislative and regulatory framework and space agency. These are all in line with best practice and position it well to leverage further growth from this start. It also appears to achieve the right balance to suit New Zealand's intention to promote private sector participation and innovation without taking on undue risks.

Partnering the US through the TSA (Technology Safeguard Agreement), encouraging trans-Tasman cooperation with Australia, taking on board any best practice developments in the US especially in regard to the encouragement of private sector participation and also in Korea in regard to government commitment/support to expanding the space industry, would be useful steps for New Zealand to take.

The proposed legislative framework focuses relatively narrowly on the area of launch services and has been rushed through to get the regulatory environment in place in timely manner to fit the commercial needs of Rocket Lab and its customers. A review in 3 years' time is included in the law and this will enable it to be both fine-tuned and expanded as necessary at that time.

Some areas to consider leading into the 3-year review are:

(i) Refine the quality of both the process and implementation of the case-by-case approvals to ensure that the rules are clearly defined, arbitrary considerations are minimised and there is an acceptable process for any competitive and conflict of interest issues that may arise.

(ii) Evaluate any gaps and avoid setting any undesirable precedents as the New Zealand space industry expands from its one-player market into a highly specialised niche area of application.

(iii) Undertake research into the environmental impact on land and water habitats and on the ozone and stratospheric black carbon layers from the high frequency of launches (120 launches per year planned by Rocket Lab plus those of any future participants) and the high failure rates common to the launch sector, and formulate appropriate guidelines for the participants.

5. Conclusions

New Zealand's entry as a spacefaring nation comes at a time when space activities are growing in importance both for life on Earth and beyond. The decision to enter appears to make good economic and ethical sense. However, a measured approach to implementation by New Zealand is warranted during the initial 3-year period as the fitness of the new act is tested by practical implementation.