MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HIKINA WHAKATUTUKI

DOIAs 1920-0789 and 1920-0808

12 December 2019

Barry Brill
fyi-request-11650-3b85b2d0@requests.fyi.org.nz, and
fyi-request-11649-3b85b2d0@requests.fyi.org.nz,

Dear Barry,

I refer to your requests, dated 14 and 19 November 2019, for information under the Official Information Act 1982 (the OIA):

> *"You have recently announced a $26 million investment in a joint venture with the US Environmental Defence Society to launch a satellite to measure methane emissions by the oil and gas industry. Please provide details of the business case supporting this investment and identify the 2019 budgetary appropriation which will fund it."*
>
> *"MBIE has announced an investment of $26 million in a satellite to detect methane emissions, in a joint venture with the Environmental Defence Society of the USA. Please provide a copy of any cabinet papers in support of this investment, including the Treasury report."*

The MethaneSAT investment was funded by a reprioritisation of funds within the Research, Science and Innovation portfolio: $20 million from the Strategic Science Investment Fund (SSIF) and $6 million from Catalyst: Strategic.

The business case for this investment was developed through several documents. I attach the material that comes within the scope of the request. Some information in the documents has been withheld under the following sections of the OIA:

- section 6(a): if the making available of the information would be likely to prejudice the international relations of the Government of New Zealand
- section 9(2)(a) to protect the privacy of natural persons
- section 9(2)(ba)(i): to protect information which is subject to an obligation of confidence where the making available of the information would be likely to prejudice the supply of similar information, or information from the same source, and it is in the public interest that such information should continue to be supplied

- section 9(2)(g)(i): to maintain the effective conduct of public affairs through the free and frank expression of opinions by or between Ministers and officials
- section 9(2) (j): to enable any Minister or department to carry on negotiations without prejudice or disadvantage.

I have also withheld the entire cabinet paper under section 18(d) of the OIA. It is currently in the process of being proactively released and will soon be available on MBIE's website.

Section 6(a) of the OIA concerns conclusive reasons for withholding information. In regard to information withheld under section 9(2), I do not consider that the withholding of this information is outweighed by public interest considerations in making the information available.

You have the right to seek an investigation and review by the Ombudsman of this decision. Information about how to make a complaint is available at www.ombudsman.parliament.nz or freephone 0800 802 602. Please contact me if you wish to discuss any aspect of your request or this response.

Yours sincerely

James Soligo
Acting Manager, Science Policy
Ministry of Business, Innovation and Employment

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

BRIEFING

New Zealand involvement in a greenhouse gas remote sensing mission

Date:	13 September 2018	**Priority:**	Medium
Security classification:	In Confidence	**Tracking number:**	0876 18-19

Action sought		
	Action sought	**Deadline**
Hon David Parker **Minister for Economic Development**	Agreement for officials to negotiate New Zealand participation in a greenhouse gas remote sensing mission.	24 September 2018
Hon Dr Megan Woods **Minister of Research, Science and Innovation**	Agreement for officials to negotiate New Zealand participation in a greenhouse gas remote sensing mission.	24 September 2018

Contact for telephone discussion (if required)				
Name	**Position**	**Telephone**		**1st contact**
Dr Peter Crabtree	General Manager, Science, Innovation and International	04 901 3907	s 9(2)(a)	✓
Dimitri Geidelberg	Principal Advisor, Space Policy and Regulatory systems	04 901 8187	s 9(2)(a)	

The following departments/agencies have been consulted
Ministry for the Environment Ministry for Foreign Affairs and Trade

Minister's office to complete:

- ☐ Approved
- ☐ Noted
- ☐ Seen
- ☐ See Minister's Notes
- ☐ Declined
- ☐ Needs change
- ☐ Overtaken by Events
- ☐ Withdrawn

Comments

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

BRIEFING

New Zealand involvement in a greenhouse gas remote sensing mission

Date:	13 September 2018	**Priority:**	Medium
Security classification:	In Confidence	**Tracking number:**	0876 18-19

Purpose

This briefing seeks a mandate for MBIE to engage on options for New Zealand participation in a space mission which would contribute to global climate change mitigation efforts.

Recommended action

The Ministry of Business, Innovation and Employment (MBIE) recommends that you:

a **Agree** that MBIE officials negotiate with the Environmental Defense Fund (EDF), and engage with domestic stakeholders, on options for New Zealand involvement in the MethaneSAT mission.

Agree / Disagree

b **Note** that following the consultations we would provide you with more detailed advice, including on costings and on securing participation in components of the mission prior to formal approval of funding through the Budget 2019 process.

Noted

s 9(2)(a)

Dr Peter Crabtree
General Manager, Science, Innovation and International
Labour Science and Enterprise, MBIE
..... / ..... / .....

Hon David Parker
Minister for Economic Development
..... / ..... / .....

Hon Dr Megan Woods
Minister of Research, Science and Innovation
..... / ..... / .....

Space is contributing to a more sustainable and secure future

1. MBIE officials are consulting with stakeholders across New Zealand on a space strategy [briefings 3401 17-18 and 0039 18-19 refer]. A clear message coming through in the consultations is that space investments can deliver against government priorities. Our objectives for economic transformation can be advanced through the growth of a knowledge-intensive and high-value space industry and through the application of space-related technology to other parts of the economy.

2. New Zealand is already heavily reliant on space assets, including for navigation, communications and national security. International comparisons suggest that there is considerable scope for productivity gains to New Zealand from greater use of Earth observation data in areas such agriculture, forestry and hazard management.

…and to New Zealand's climate change leadership role

3. As well as working towards a net zero carbon economy, New Zealand seeks to be a global leader in addressing climate change. The Minister for Trade and Export Growth, the Minister for Foreign Affairs and the Minister for Climate Change will jointly be taking a paper to Cabinet articulating how New Zealand can be a global leader on climate change and why it should. Participation in global science collaborations provides opportunities to exercise such leadership, and New Zealand's emergence as a space actor opens up avenues for additional action.

4. In conjunction with French President Emmanuel Macron's One Planet Summit last December, the French space agency (CNES) invited New Zealand to participate in the creation of the Space Climate Observatory (SCO). Pooling together resources from participating countries, the SCO will use Earth observation data to analyse, model and monitor climate change to improve mitigation effects and to manage its impacts. MBIE and NIWA will be participating in an SCO meeting in the margins of the International Astronautical Congress (IAC) taking place in Germany in early October this year.

Space missions will accelerate our industry development

5. In earlier briefings we have provided advice on options to accelerate the development of New Zealand's space industry, including through science collaborations [briefings 2529 17-18, 3508 17-18 and 0325 18-19 refer] and developing a new space 'platform-play' [briefing 2734 17-18 refers].

6. One of the strongest messages relayed to us during the strategy consultations is that the fastest way to build domestic capacity is to invest in space missions. Enabling New Zealand researchers and engineers to design, build, launch or control satellites will develop critical skills and knowledge, as well as international credibility.

7. The overall value of a space mission will be enhanced if its focus aligns with national priorities. For example, a mission that improves New Zealand's capacity to monitor greenhouse gas emissions or activity in our Exclusive Economic Zone would deliver benefits additional to those of building space industry capability.

8. Given the relatively thin capability in our space industry at present (with the exception of Rocket Lab), there would be clear advantages in undertaking space missions in partnership with credible international partners.

We have been invited to join a greenhouse gas remote sensing mission

The mission will focus on methane

9. We have provided a brief note to the Minister of Research, Science and Innovation on the invitation from the Environmental Defense Fund (EDF) to participate in the MethaneSAT mission and had a preliminary discussion on this topic. We provide further details in this briefing.

10. EDF is a US environment and conservation non-government organisation of 50 years standing. EDF has 700 staff working in 15 countries, and in 2017 its operating budget was USD182 m. EDF is leading MethaneSAT, a mission to develop, launch and operate a satellite that will provide data on anthropogenic methane emissions with much greater resolution than existing satellites.

11. EDF considers a focus on methane to offer the fastest and cheapest path to reduce global greenhouse gas emissions. In contrast to carbon dioxide, methane only persists in the atmosphere for around a decade. It is however is a powerful greenhouse gas, with around 30 times the global warming effect of carbon dioxide.

12. The mission's primary focus will be measuring surface methane emissions from the oil and gas sector. It will target around fifty major oil and gas producing regions that account for more than 80% of global production. By identifying sources and volumes of methane emissions, the satellite would provide industry and regulators a tool to target remediation efforts and measure progress.

13. The satellite will also have some capacity to measure emissions from others sources such as agriculture and landfills. This is of relevance to New Zealand given that methane also accounts for nearly 50% of New Zealand's total greenhouse gas emissions (in terms of global warming potential).

14. Participation in this mission would provide a tangible demonstration of New Zealand's commitment to tackling climate change. It would be an entry point for participation in the SCO and other global initiatives. As a space agency, we would also seek to build national buy-in to the mission. There is, for example, considerable scope to engage schools and shape an educational element to this project.

There are significant industry capability opportunities

15. We understand that some of the key technologies for the satellite have been identified, however we would need to explore with EDF the scope for technology development and engineering opportunities that remain before the satellite is ready for launch (planned for 2021).

16. We have also discussed the project with Rocket Lab CEO Peter Beck. Rocket Lab is interested in launching the satellite from New Zealand and in some of the engineering challenges that would be involved.

17. Establishing a mission control centre in New Zealand, particularly if combined with launch from New Zealand, would provide valuable, practical experience in sending a satellite into space and controlling it while in orbit. We would need to consult with all relevant stakeholders before providing further advice. s 9(g)(i) and s 9(2)(j)

…and potential science collaborations

18. As noted above, MethaneSAT will primarily target the oil and gas industry. While its sensors will be more sensitive than those of existing satellites, detecting the exact source of methane emissions from pastoral agriculture, and calculating volumes, is likely to be at the limit of its capabilities, at least in the initial phase. New Zealand's cloud cover and wind are likely to present additional challenges.

19. New Zealand has recognised capability in validation and calibration of satellite data through ground-based sensors. NIWA's Lauder atmospheric laboratory is being used for calibration of a number of satellites making atmospheric gas measurements and is seen as globally important for doing so because of New Zealand's unique location in the world. NIWA has, for example, been working with NASA to improve the accuracy of satellite based measurement of carbon dioxide.

20. Applying New Zealand's expertise and geographic advantages to methane remote sensing would, over time, improve the quality of the data collected by the satellite. In the longer term, New Zealand would help advance the overall field of greenhouse gas remote sensing. Collaboration in the mission may also open opportunities for research collaboration with Harvard University which is partnering with EDF in the mission.

We estimate that $5m per annum would be required for participation in the project

21. EDF has estimated the total mission budget as USD50m. However, this excludes mission control and science costs. Our preliminary view is that New Zealand funding could include a contribution towards design and launch costs, and cover mission control costs, including up-front equipment purchases. To maximise the value in participation we could cover New Zealand science costs, including calibration/validation and algorithm development. Our initial estimate is that $5m would be required for this level of involvement.

We would need to prepare a Budget bid but the time frames may be complex

22. MBIE, in consultation with other agencies, will develop a bid for Budget 2019 for a Strategic Science Investment Fund platform focused on space science. This would form the cornerstone of a New Zealand Space Programme. The MethaneSAT mission could be the platform's first major deliverable.

23. We understand that EDF are intending to lock in some key decisions in the coming months, potentially in advance of Cabinet consideration of Budget bids. We may therefore need to provide you with advice on options to secure our interests in the mission in advance of formal funding approval.

Next steps

24. Should you agree to officials negotiating possible involvement in the MethaneSAT mission, we would meet with the EDF project leaders to identify the most promising options and to get clarity on their timelines and processes. s 9(g)(i) and s 9(2)(j) We would also identify risk management requirements, eg whether technical assessments were required.

25. Following the consultations we would provide you with more detailed advice on the mission's expected outputs, the scope of New Zealand participation, and costings for the different participation options.

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
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BRIEFING

Greenhouse gas satellite mission – discussions with the Environmental Defense Fund

Date:	6 December 2018	**Priority:**	Medium
Security classification:	In Confidence	**Tracking number:**	1440 18-19

Action sought		
	Action sought	**Deadline**
Hon David Parker **Minister for Economic Development**	Agreement to MBIE indicating in principle interest in participating in the MethaneSAT mission.	17 December 2018
Hon Dr Megan Woods **Minister of Research, Science and Innovation**		17 December 2018
Hon James Shaw **Minister for Climate Change**		17 December 2018

Contact for telephone discussion (if required)				
Name	**Position**	**Telephone**		**1st contact**
Kirsty Hutchison	Acting Manager, Space Policy and Regulatory Systems	04 901 4131	s 9(2)(a)	
Dimitri Geidelberg	Principal Policy Advisor, Space Policy	04 901 8187	s 9(2)(a)	✓

The following departments/agencies have been consulted
Ministry for the Environment Ministry of Foreign Affairs and Trade

Minister's office to complete:

☐ Approved ☐ Declined
☐ Noted ☐ Needs change
☐ Seen ☐ Overtaken by Events
☐ See Minister's Notes ☐ Withdrawn

Comments

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

BRIEFING

Greenhouse gas satellite mission – discussions with the Environmental Defense Fund

Date:	6 December 2018	**Priority:**	Medium
Security classification:	In Confidence	**Tracking number:**	1440 18-19

Purpose

This briefing updates you on officials' discussions with the Environmental Defense Fund (EDF) on a remote sensing greenhouse gas mission and seeks your approval to give an in principle indication of interest for New Zealand participation in the mission.

Recommended action

The Ministry of Business, Innovation and Employment (MBIE) recommends that you:

a **Note** that New Zealand has the opportunity to develop its space sector capability and contribute to global efforts on climate change through partnering in the MethaneSAT mission

Noted

b **Agree** that New Zealand give EDF an in principle indication of interest in:

a. establishing and operating a mission control centre for the mission, including any required infrastructure
b. leading the agriculture science component of the mission
c. pre-launch testing, calibration and research

Agree / Disagree

c **Note** that a pre-Budget commitment of funding to the MethaneSAT mission would give New Zealand greater influence over mission planning.

Noted

s 9(2)(a)

Kirsty Hutchison
Acting Manager, Space Policy and Regulatory Systems
Labour, Science and Enterprise, MBIE

..... / ..... / .....

Hon David Parker
Minister for Economic Development

..... / ..... / .....

Hon Dr Megan Woods
Minister of Research, Science and Innovation

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Hon James Shaw
Minister for Climate Change

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We have been investigating the opportunity to partner in a climate change focused space mission

1. You have agreed that we proceed with discussions with the Environmental Defense Fund (EDF) to determine the scope for New Zealand's participation in MethaneSAT, a methane remote sensing mission [briefing 0876 18-19 refers]. EDF is a US environment and conservation non-government organisation with 700 staff working in 15 countries, and an annual operating budget of over USD180 m. EDF is leading MethaneSAT, a mission to develop, launch and operate a satellite that fills a gap in methane remote sensing capability.

2. We met with EDF's MethaneSAT team during the International Astronautical Congress (IAC) in Bremen and at EDF's headquarters in New York, including with Dr Steve Hamburg and Tom Ingersoll. Hamburg is EDF's Chief Scientist and has been involved in biogeochemistry and forest ecology research for over 35 years, notably at Brown University. Ingersoll was brought in to head the mission after a 25 year career in the space and telecommunications industry, including as CEO of high resolution satellite imagery company, Skybox.

We have opportunities to develop our space sector and use space as a platform to benefit life on Earth

The mission aligns with our objectives of fast-tracking space sector capability through investing in space missions

3. Officials are working on a New Zealand Space Programme Budget bid designed to accelerate the development of New Zealand's nascent space industry, notably through improving human capital. The Budget bid would enable New Zealand to:

    - develop a base level of science and engineering capability to provide a pipeline of talent for the space launch industry (currently heavily dependent on skills from overseas)
    - leverage our frequent launch capability to grow a 'new space' research and development hub based on a rapid product development cycle (design-protoyping-testing-refining)
    - apply capabilities developed through the space sector to challenges such as increasing agricultural productivity, decarbonising the economy, and improved management of natural hazards.

4. One of the strongest messages relayed to us during consultations on a space strategy is that investing in space missions would provide a pathway to rapidly build domestic capability. Enabling New Zealand researchers and engineers to design, build, launch or control satellites will develop critical skills and knowledge, as well as international credibility. Funding for leading and participating in space missions is a key component of the Space Programme Budget bid.

5. MethaneSAT presents a valuable opportunity as New Zealand's first space mission. It is the right fit for our current objectives in respect of its scale, timeframes (launch in 2021) and the opportunity to partner with a credible organisation.

6. EDF would be happy for New Zealand to establish and **operate a mission control centre** and would engage with us on what an operations centre would require. s 9(2)(g)(i) and s 9 (2)(j)

7. EDF is looking at New Zealand as an option for **launch**. On current plans the satellite could be launched on a Rocket Lab Electron, though further design work would need to be done

before this could be confirmed. EDF have secured the majority of the funding required for the mission but launch costs, along with mission control and agricultural emissions science, remain a gap that New Zealand could usefully cover. A contribution towards launch would also help cement this space mission as a New Zealand one.

8. Participation in the mission would reinforce MBIE's other work in developing the space sector, such as: the partnership with the German Aerospace Center (DLR), including a collaborative research programme with Catalyst Fund support [briefing 2529 17-18]; the Catalyst Fund call for space science collaboration [briefing 0325 18-19 refers]; the NASA internships; and the Innovative Partnerships space sector platform play [briefing 2734 17-18 refers], including the partnerships secured to date with Airbus and LeoLabs.

New Zealand could rapidly advance agricultural emissions remote sensing science

9. As well as building domestic capability, MethaneSAT provides New Zealand the opportunity to help address a major global challenge. The mission would contribute to rapid monitoring of global methane emissions, filling an identified gap in current remote sensing technology (see below).

10. Participation in this mission would provide a tangible demonstration of New Zealand's interest in exercising leadership in tackling climate change. It would be an entry point for participation in the French-led Space Carbon Observatory (launched last year in conjunction with President Macron's One Planet Summit) and other global initiatives.

11. In order to maintain mission focus, EDF and Harvard University (which is leading the mission's overall science programme) have focused their planning on oil and gas industry emissions. However, they are keen for the satellite to be applied to agricultural emissions. EDF would be very enthusiastic about the prospect of a New Zealand institution taking the **lead on the agricultural emissions science** side of the mission. New Zealand's geographic advantages and expertise in calibration and validation of satellite data (such as at NIWA's Lauder research centre in Central Otago) could be valuable for the mission, including as potential initial contributions. Acknowledging that this is an area where New Zealand has less expertise, they would also like the mission to cover emissions from rice paddies, a major known source of methane.

12. EDF is keen to set up a discussion with New Zealand scientists to explore the satellite's limits of detection for emissions from pastoral agriculture. Whether or not the satellite will be able to meet New Zealand's measurement needs at this point in time, the mission will put New Zealand researchers at the forefront of detection and measurement of agricultural methane emissions from space. In future, this knowledge could be integrated into domestic research programmes such as those of the New Zealand Agricultural Greenhouse Gas Research Centre.

13. Leading on agricultural emissions science would also enable further research and teaching opportunities in New Zealand institutions. In addition to greenhouse gas science, EDF sees data science and social science opportunities from the mission.

This mission reinforces our brand and values

14. New Zealand is positioning itself as a 'new space' nation, with an innovative commercially-driven space sector. The IAC in Bremen provided an opportunity to test our "New Space New Zealand" brand. Our messaging focused not only on highlighting the advantages New Zealand has for commercially-driven, 'New Space' activities, but also on the innovative thinking we bring to space. This resonated with a wide industry and research audience.

15. In our conversations at IAC we also explained how our deliberations on a space strategy led us to reflect on our *values* as a space faring nation. In a practical sense this meant we would

prioritise those initiatives that could use our capability in space to make a positive global impact.

16. EDF is enthusiastic at the prospect of New Zealand participation in the mission. Apart from the benefits of financial and practical support, EDF considers that New Zealand's strong global brand would bring profile and additional credibility to the mission. For New Zealand, a partnership with a well-established and credible non-government organisation would further reinforce New Zealand's brand as a forward-thinking space actor committed to contributing to life on Earth.

Contributions to the mission would be the focus for early funding under the Space Programme Budget bid

17. EDF has estimated the mission budget at around USD60m, excluding mission control and agricultural science costs. Our initial estimate is that a New Zealand contribution of around NZD2-3m per annum would be required for those two categories. Higher expenditure of up to NZD8m would be required in each of the first two years (2019/20 and 2020/21) for capital costs to set up a mission control centre and a contribution to launch costs. The Space Programme Budget Bid is seeking up to NZD10m per annum to provide funding for multiple space missions over time, as well as for scholarships.

Significant thought and planning has gone into the mission

EDF have been heavily involved in the science of methane detection and measurement

18. EDF have been working on methane for over six years and have published a number of scientific papers. They have sought to address major gaps in data on methane emissions in the oil and gas industry. Using mobile ground sensors and air sensors, an EDF-led research team found that US oil and gas methane emissions were around 60 per cent higher than the US Environmental Protection Agency inventory estimate (paper published in *Science* in June 2018). Detection of specific leaks identified during this work enabled EDF to engage with companies and public utilities on remediation work. All the data was posted publicly and, despite EDF's initial concerns, there was no pushback. The ongoing leak detection has now been taken over by the private sector.

19. EDF is designing the mission to generate policy relevant data. However, EDF maintains a sharp separation of its science from its advocacy campaigns. The mission budget does not include provision for advocacy work. EDF has put significant effort into engaging with US oil and gas industry scientists to achieve shared understanding of the data and analysis. s 9(2)(ba)(i) .

20. The science work of the mission will be led by Steve Woofsy, Professor of Atmospheric and Environmental Science at Harvard University, with support from the Smithsonian Astrophysical Observatory. EDF is also pulling together a science advisory group for the mission and wants to include industry scientists.

MethaneSAT will push detection technology

21. MethaneSAT will fill a gap in detection and measurement capability. Current and planned satellites such as Japan's GOSAT and the European TROPOMI mission are able to provide global coverage through their wide view paths but have low pixel resolution (tens of km). At the other end of the spectrum, satellites operated by GHGSat (on whose governing board Ingersoll sits) have a very high pixel resolution (50m) but very narrow view path to provide commercial monitoring and measurement services for specific sites.

22. MethaneSAT's 200 x 200 km view path will enable monitoring of known emissions and identification of unknown sources. The satellite will have a pixel resolution as high as 200 m and be able to detect fairly low column methane concentrations (down to two parts per billion). It will have a revisit time of less than five days and have the capacity to point the sensor. s 9(2)(ba)(i)

23. The sensor technology required to meet these specifications does not currently exist on the market. However, discussions with leading instrument suppliers have led EDF to conclude that it can be developed. Two companies have been shortlisted for a competitive design phase, and a decision on the final supplier will be taken by the end of the year.

24. After the satellite has been launched into space there will be no chance to make any adjustments to the sensor. EDF will therefore test the instrument on board a US National Science Foundation aircraft. Once the satellite is operational, solar spectrometers will be used to look at the air column from the ground up in order to validate the data from the satellite.

The mission will have short timeframes but follow established protocols

25. When compared to the timeframes for most space missions, those for MethaneSAT will be relatively short. EDF has a 36 month schedule, with launch planned in 2021. They are, however, following a traditional mission development process such as used by NASA. Aside from the sensor, all other satellite technologies are based on those currently on the market. Satellite integration and pre-launch testing will be procured from proven commercial providers. EDF has drawn together an experienced mission advisory group, including the Chief Scientist at NASA's Jet Propulsion Laboratory.

26. s 9(2)(ba)(i)

Risks and mitigations

27. We recommend giving EDF an early indication of our interest in participating, in order to be able to **influence key decisions** that will shape the mission. However, there would be **reputational risk** were the Space Programme Budget bid (from which we would fund our participation) not to succeed.

28. EDF is managing the **technical risks**, inherent in any space mission, by bringing in extensive experience through the team leader and advisory group and by following well-established processes. The mission is reliant on sensor technology that is new to market, and so EDF is running a staged procurement process and a pre-launch testing phase.

29. MBIE has an advisory contract in place with Dr Delwyn Moller (whose career has included working at NASA's Jet Propulsion Laboratory) and we are drawing on our relationship with the Defence Technology Agency for additional advice. Early involvement of collaborating New Zealand institutions would also be important.

30. As an environmental NGO, EDF has been very sensitive to the risk of **challenges from industry** to the data (in the same way that industry-funded research may be challenged by advocacy groups). EDF has focused on developing and achieving consensus on the science in advance of launching the satellite. MBIE's connections with space agencies and international research networks would reinforce this. s 6(a)

Next steps

There would be advantages in signalling in principle interest at this stage

31. EDF indicated that New Zealand's level of participation in mission decision-making would be adjusted depending on our level of involvement, including in mission planning were we to signal our involvement at a sufficiently early stage. Rather than waiting until May next year we would recommend signalling *in principle* interest in elements of the mission and starting to influence decisions that align with our interests. The more certainty we can give EDF regarding our intentions, the greater our influence over mission planning. A pre-Budget commitment of funding to the mission could be considered.

32. Should you agree with the recommendations in the briefing, we would further engage with EDF on the key avenues for New Zealand involvement in the mission, including in regard to the decision making processes. We would also engage with the relevant New Zealand research institutions to establish a mechanism for EDF and Harvard to engage in a streamlined way with the New Zealand science system.

Out of Scope

From: Rachel Ward [mailto:Rachel.Ward@parliament.govt.nz]
Sent: Tuesday, 22 January 2019 1:55 p.m.
To: Dimitri Geidelberg
Cc: Laurette Siemonek; Lesley McConnell; Sean Torbit (Parliament); Andrew Johnson; Deborah Burgess; MACFARLANE, Kate (ISED)
Subject: RE: Greenhouse gas satellite mission briefing

Hi Dimitri,

Minister Shaw asked me to thank you for this note, and has no further comments.

Thanks
Rachel

From: Dimitri Geidelberg [mailto:Dimitri.Geidelberg@mbie.govt.nz]
Sent: Thursday, 17 January 2019 4:43 PM
To: Rachel Ward <Rachel.Ward@parliament.govt.nz>
Cc: Laurette Siemonek <Laurette.Siemonek@parliament.govt.nz>; Lesley McConnell <Lesley.McConnell@parliament.govt.nz>; Sean Torbit <Sean.Torbit@parliament.govt.nz>; Andrew Johnson <Andrew.Johnson@mbie.govt.nz>; Deborah Burgess <Deborah.Burgess@mfe.govt.nz>; MACFARLANE, Kate (ISED) <Kate.Macfarlane@mfat.govt.nz>
Subject: RE: Greenhouse gas satellite mission briefing

Rachel

This email responds to Minister Shaw's request for additional information on greenhouse gas remote sensing satellites and their capabilities, as well as his query about whether MethaneSAT would be using the best detection technology available.

Measuring greenhouse gas emissions from space is a fairly recent development (starting with the European Space Agency's Envisat/SCIAMACHY mission which operated from 2002 to 2012). Greenhouse gas science is advancing by aggregating the output from the various missions with their relative strengths in generating different data sets. The quality of satellite data is also improved through ground-based calibration, including NIWA's work at the Lauder research centre. The MethaneSAT mission provides an opportunity for New Zealand to be more involved in this global endeavour.

Attached is a table setting out current and planned satellite missions which have the capability to measure a range of different greenhouse gases. We have restricted the list to satellites with air column observation instruments and with greenhouse gas measurement as a primary focus. There are many more meteorological satellites that include instruments capable of detecting carbon dioxide, methane and gases such as ozone and nitrous oxide but primarily for the purposes of measuring air pollution, the state of the ozone layer etc.

The table summarises a few key specifications for each of the satellites. A basic trade-off in this field of remote sensing is between the resolution and the swath (or view path width). Europe's TROPOMI instrument on the Sentinel-5P satellite has a very wide swath that provides global coverage. However, the pixel resolution is fairly course (7km x 7km), making it hard to pinpoint the source of gas emissions. At the other end of scale, Canada's GHGSat satellites will provide images with 50m x 50m pixel resolution. However they have very narrow swaths and they are designed for monitoring *known* emissions sources, eg a particular gas field, rather than providing global coverage. Due to lack of published information we have not included in the table the satellite mission announced last September by California Governor Jerry Brown but we understand that it would be similar in capability to GHGSat's.

Ultimately, the technology choices made for each satellite will depend on the mission's objectives. In many cases a mission will involve constellations of multiple satellites providing complementary data. The MethaneSAT mission is seeking to fill a gap in capability – a wide enough swath to enable global coverage but sufficient resolution to identify emission sources. Hitting this 'sweet spot' will require developing a state-of-the-art sensor.

There are some gaps in the attached table reflecting the fact that the public information on the specifications for some of the satellites does not include the particular parameters we have chosen for this comparison as well as information gaps for future missions. s 6(a)

[redacted]

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Dimitri Geidelberg
Principal Policy Advisor
Space Policy

MINISTRY OF BUSINESS INNOVATION & EMPLOYMENT | HIKINA WHAKATUTUKI
15 Stout St, Wellington, New Zealand | +64 4 901 8187

Greenhouse Gas Observation Satellites

Mission	Country / Agency	Data period[1]	Gases	Precision parts per million(ppm), parts per billion (ppb)	Pixel size	Swath (km)	Other Details
Current Missions							
Fengyun-3D	China (NSMC)	2017-2022	CO_2, CO, CH_4, N_2O		13 km diameter	100	
Gaofen5	China (CAST)	2018 -2026	CO_2, CH_4		10 km diameter	800	
GHGSat-D Claire	Canada (GHGSat)	2016 -	CO_2, CH_4		0.05 km x 0.05 km	12	Demonstrator satellite. Commercial services.
GOSAT	Japan (JAXA)	2009-	CO_2, CH_4	CO_2: 4 ppm CH_4: 34 ppb	10 km diameter	750	
GOSAT2	Japan (JAXA)	2018-2023	CO_2, CH_4	CO_2: 0.5 ppm CH_4: 5 ppb	10 km diameter	1000	
MetOp / IASI	EUMETSAT / France (CNES)	2006 -	CO_2, CO, CH_4, N_2O, O_3		12 km x 12 km	2200	Three EUMETSAT satellites in this mission MetOp A, B and C
OCO2	US (NASA-JPL)	2014-2019	CO_2	1 ppm	1.3 km x 2.2 km	10.3	Successor to OCO1 which was lost due to launch failure in 2009
Sentinel-5p / TROPOMI	EU / EUMATSAT /ESA	2017 -2022	CO_2, CO, CH_4, N_2O, O_3	CH_4: 11 ppb	7 km x 7 km	2600	

[1] Estimated period during which the satellite will be transmitting data. The life of the mission may be extended depending on the state of the satellite.

TanSat	China (CAS)	2016	CO_2	4 ppm	1 km x 2 km	400	The main Chinese GHG satellite
Planned Missions							
MethaneSAT	EDF	2021 -2023	CH4, CO	CH_4: 2 ppb	1 km x 0.2 km	200	
ASCENDS	US (NASA)		CO_2				LiDAR instrument; day and night monitoring
GeoCarb	US (NASA-JPL)	2022 - 2027	CO_2, CO, CH_4	CO_2: 2.7 ppm CH_4: 18 ppb CO:10 ppb	4 km x 5 km	2800	geostationary over Americas
GHGSat-C1 &C2	Canada (GHGSat)	2019 -	CO_2, CH_4				Commercial services.
GOSAT3	Japan (JAXA)	2022-2028	CO_2, CH_4				
MetOp SG/ IASI NG	EUMETSAT / France (CNES)	2021 - 2042	CO_2, CO, CH_4, N_2O, O_3		9 km x 12 km	2130	Three MetOp SG satellites in this mission
ISS-OCO3	US (NASA-JPL)	2019 - 2024	CO_2	1 ppm	1.3 km x 2.2 km	10.3	OCO2 instrument spares – flown on board the International Space Station
MERLIN	Germany (DLR) and France (CNES)	2021-2024	CO_2, CH_4		0.15 km x 0.15 km		LiDAR instrument demonstrator
MicroCarb	France (CNES)	2021-2026	CO_2, CH_4	CO_2: 1 ppm	4.5 km x 9 km	13.5	

Budget Initiative: New Zealand Space Programme

Overview and context

Key Question/area	Comment/answer
Agency to complete	
Portfolio of lead Minister	Research, Science and Innovation
Portfolio(s) of other Ministers involved (if this is a joint initiative)	
Votes impacted	Business, Science and Innovation
Initiative title	*New Zealand Space Programme*
Initiative description	This funding will enable economic transition through accelerating the development of a high wage, research and development (R&D) intensive space industry. It will improve human capital and maximise returns to New Zealand from new commercial opportunities and R&D investment. It will also generate knowledge spillovers that will benefit national priorities such as agricultural productivity, natural resource management, maritime domain awareness and disaster risk management. The funding will accelerate capability development by enabling New Zealand students and researchers to lead and participate in space missions. In the initial phase, this will involve New Zealand being a joint partner in an innovative, high-profile mission focused on greenhouse gas remote sensing. Taking advantage of New Zealand's frequent launch capability, the funding will enable New Zealand students and researchers to design, build, launch and test equipment on a regular basis, spurring the creation of a rapid product development hub. The initiative will also provide scholarships and internships for New Zealand students to study at world-leading space research centres and enable New Zealand institutions to provide scholarships to attract talented researchers from overseas.
Type of initiative	**Priority aligning**
If this initiative relates to a priority, please outline the specific priority/ies it contributes to	• Creating opportunities for productive businesses, regions, iwi and others to transition to a sustainable and low-emissions economy • Supporting a thriving nation in the digital age through innovation, social and economic opportunities.
Does this initiative relate to a commitment in the Coalition Agreement, Confidence and Supply Agreement, or the Speech from the Throne?	The initiative is part of the Research, Science and Innovation package that delivers against the Labour/NZ First Coalition Agreement commitment to work to increase R&D to 2% of GDP over ten years. The initiative is focused on developing a high-value, low-carbon and R&D-intensive industry that also generates knowledge spillovers for de-carbonising other sectors of the economy. It relates to two elements of the Speech from the Throne : • A shift is required to create a more productive economy…This means working smarter, with new technologies… and adding more value in New Zealand. For

	example… more research and development to add value to dairy and other products and to create new technologies • Climate Change - This government will set a target of a Net Zero Carbon Emissions Economy by 2050. It also relates to the Labour Green Confidence and Supply Agreement: • Sustainable Economy: Adopt and make progress towards the goal of a Net Zero Emissions Economy by 2050, with a particular focus on policy development and initiatives in transport, urban form, energy and primary industries.
Agency contact	Dimitri Geidelberg Principal Policy Advisor, Space Policy MBIE Tel: 04 901 8187; Mob s 9(2)(a) dimitri.geidelberg@mbie.govt.nz
Responsible Vote Analyst	Danielle Lucas

Funding

Funding Sought ($m)		2019/20	2020/21	2021/22	2022/23 & outyears[1]	TOTAL
Operating		4	10.3	9.3	10.3	33.9

Funding Sought ($m)		2019/20	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	TOTAL
Capital[2]	2	-	-	-	-	-	-	-	-	-	2

1. Executive Summary

1.1 EXECUTIVE SUMMARY

A. Short summary of the proposed initiative and expected outcomes.

The Government has moved quickly to establish a regulatory regime and a space agency within MBIE to enable Rocket Lab to launch from New Zealand. This has in turn focused global attention on New Zealand and assisted MBIE in unlocking valuable partnerships with major space agencies and multinational aerospace firms. There is now an opportunity to position New Zealand as a significant player in the 'new space' industry (characterised by dynamic, entrepreneur-driven and venture-capital funded space companies).

Human capital is a key constraint to expanding the domestic industry. New Zealand has pockets of world-class expertise, but overall space science and engineering capability is thin. At present, Rocket Lab is highly dependent on overseas talent.

This initiative will accelerate the development of space sector science and engineering skills by providing funding for New Zealand researchers and engineers to lead and participate in space missions. The first mission will involve partnering with a large, credible environmental organisation on an innovative, high profile satellite mission focused on greenhouse gas emissions. As well as providing skills development benefits, participation in this mission will make a contribution to greenhouse gas remote sensing science and will enhance New Zealand's global reputation.

[1] If funding is time-limited and does not carry on into out-years please delete the reference to "& outyears"

[2] The first 10 years of capital investment is counted against the multi-year capital allowance. Please reflect the full 10 year profile in the table.

Taking advantage of New Zealand's frequent launch capability, the initiative will provide funding for rapid product development research (design-protoyping-testing-refining).

This initiative will further drive capability development by allowing New Zealand's best students to deepen their knowledge through internships and longer term study at world-leading institutions. Scholarships will also be provided to enable talented overseas students to undertake their research in New Zealand.

This initiative will generate important spillover benefits. The knowledge and skills developed through the missions, research and training, will underpin space-enabled solutions to national priorities, for example in supporting precision agriculture, water quality monitoring, and maritime domain awareness.

If this investment is not made, New Zealand will lose the opportunity to fully capitalise on the presence of a world-leading launch capability. Industry development will proceed at a much slower pace and will be less resilient in the face of international competition. The New Zealand Space Agency will not be able to extract full value from partnerships with other space agencies, and the Innovative Partnerships programme will have less scope to attract globally leading space sector firms and innovators. Further transition opportunities will be lost as New Zealand will be less able to apply space-enabled technologies to other sectors. The Government would also not be in a position to fully support efforts by domestic stakeholders such as the establishment of the University of Auckland's Space Systems Institute.

2. The Investment Proposal

This section asks you to outline your overall investment proposal and intervention logic. It should be supplemented with a one page intervention logic map showing the progression from outputs, outcomes and impacts of the initiative. See template 5 for an example of an intervention logic map that you can use as a template or guide.

2.1 Description of the initiative and problem definition

What is this initiative seeking funding for?

This is a new initiative that supports the first two Budget 2019 focus areas:

- Creating opportunities for productive businesses, regions, iwi and others to transition to a sustainable and low-emissions economy
- Supporting a thriving nation in the digital age through innovation, social and economic opportunities

The initiative seeks new funding to be used for the following:

- Researcher costs, capital costs, and procurement of services (including launch) to enable New Zealand to lead and participate in space missions and rapid product development projects
- Scholarships and internships for high-achieving New Zealand students to study and gain work experience at international space agencies (such as NASA and the European Space Agency - ESA), overseas academic institutions and aerospace firms
- Scholarships for overseas students to undertake PhD and postdoctoral research in New Zealand in fields aligned with domestic industry development priorities.

Why is it required?	The Budget 2019 package of research, science and innovation (RS&I) bids delivers the sustained and increasing investment needed to achieve the Government's target of raising economy-wide research and development (R&D) investment to two per cent of GDP by 2027. Coordinated effort across a number of portfolios is needed to achieve key Government objectives. Achieving the transformational change envisioned by those objectives requires greater investment in research, science and innovation (increasing our knowledge capital). It also requires making the most of the existing investments, knowledge, and skills in our public research institutions (our existing knowledge capital). R&D and innovation are key factors in that coordinated effort because new knowledge and new ways of working are important tools to: a. create and improve ways to sustainably generate wellbeing from our capital stocks b. understanding how to protect and grow capital stocks c. understand and measure current wellbeing, capital stocks, their interactions, risk and resilience. As a measure of the resources needed to create the change envisioned, the Government set a target of raising economy-wide R&D investment to two per cent of GDP over ten years. Maintaining the momentum needed to meet the two percent target is important to prevent delaying contributions to increased wellbeing. It will also create a structured and well signalled economy-wide pathway to undertake increasing levels of R&D, and reduce pressures on future years (particularly if private sector contributions to R&D do not increase at the expected rate). This initiative is part of a package designed to achieve the Government's two percent target by increasing the knowledge capital needed to meet Budget 2019 priorities. This initiative focuses on the space sector which is globally connected, R&D-intensive and an important source of innovation. Rocket Lab's presence in, and launches from, New Zealand - underpinned by the development of an enabling regulatory regime and international agreements - now provides the opportunity to grow our domestic space sector by positioning New Zealand as a hub for 'new space' activities. New Zealand does not have a traditional space sector driven by large government-funded research programmes. This brings the benefit of enabling sector growth unencumbered by legacy decisions and investments. However, the lack of a legacy also means New Zealand's space sector is thin and fragmented. New global interest in New Zealand, coupled with targeted government engagement, has unlocked new partnership arrangements. This includes the New Zealand Space Agency's relationships with NASA, the German Aerospace Centre (DLR), and the European Space Agency (ESA), as well as the arrangements with Airbus and LeoLabs secured through the Innovative Partnerships programme. Other agreements are under negotiation. While some funding is available to support these partnerships, a step change in space-related investments would be required to deliver on their full potential. New Zealand institutions, including the University of Auckland and the University of Canterbury are positioning themselves to take advantage of new international collaboration opportunities, including through the establishment of a new Space Systems Institute in Auckland (through Entrepreneurial Universities funding). This Budget initiative will result in greater impact from these domestic efforts, resulting in more, and better trained, space scientists and engineers for a growing industry. The initiative seeks to rapidly develop human resource capability to meet the labour force needs of

	the domestic small launcher industry that has already developed. It aims to make that sub-sector more resilient in a market that is both increasingly competitive and that governments around the world are enthusiastically subsidising for its prestige value. Leveraging the opportunity provided by frequent launches from New Zealand, this initiative will help in growing an R&D hub, making the domestic benefits broader and longer lasting. The initiative further aims to support the expansion of New Zealand's space sector beyond launch by developing skills in areas such as satellite sensor development, mission control and data analysis. s 9(2)(g)(i)
2.2 Options analysis and fit with existing activity	
What other options were considered in addressing the problem or opportunity?	Maintaining the status quo was considered as an alternative, ie limited funding support through existing mechanisms – see below. This approach would preclude substantial participation in missions which is seen by industry stakeholders as a high impact intervention for building fundamental capability. It would also not support priority niche capability, eg greenhouse gas remote sensing science. Current arrangements would also leave little scope to fund research for rapid prototyping and testing of new space technologies. There is also no funding envelope available for an expansion of the internships scheme or for funding space scholarships. There are already opportunities available to extend the internships scheme to other NASA centres and other space agencies but these cannot be funded at present.
What other similar initiatives or services are currently being delivered?	Funding has been set aside under the Catalyst Fund to support international space science collaborations. In the short term, this will be in the form of a negotiated joint research programme with Germany's DLR and a contestable call for proposals for joint research with institutions in a small number of countries. Funding has been allocated for a trial of internships with NASA's Ames Centre. In the first round, 211 applications were received for the four places that can be supported with existing funds.
What other, non-spending arrangements in pursuit of the same objective are also in place, or have been proposed?	The initiative would build on the work establishing and implementing a regulatory regime for outer space activities. The initiative complements the Innovative Partnerships programme's work on a space sector platform play. MBIE is also leading the development of a New Zealand Space Strategy which will focus on wider national interests in space (including economic, social, environmental, diplomatic, and security). This initiative responds to stakeholder feedback from the strategy consultation process and thinking within government on emerging strategic priorities. MBIE has been negotiating partnerships with overseas space agencies and multinational firms to secure training and research opportunities, and R&D investments. MBIE has also been engaging with, and supporting, domestic research and industry stakeholders, eg hosting the New Zealand stand at the International Astronautical Congress.
Strategic alignment and Government's priorities/direction	As set out in section 2.1 above, this initiative contributes to the first two Budget 2019 focus areas. At the agency level, this initiative strongly aligns with MBIE's purpose "to grow New Zealand for all". It delivers against the first goal of MBIE's Statement of Intent 2018-2022 and MBIE's purpose and outcomes framework: "economic performance through productive and sustainable use of resources across New Zealand". It aligns with four of the five MBIE goals:

- Prosperous and adaptable people, sectors, and regions
- People are skilled and engaged in safe and fulfilling work
- Value is sustainably derived from the natural environment
- A dynamic business environment fostering innovation and international connections.

The initiative is closely aligned to priorities emerging through the RS&I strategy development process. Space Economy and RS&I for a Zero Carbon Future are two of the themes identified for in-depth specialisation. The strategy is likely have a focus on high-tech innovative firms and on engaging in strategic international relationships to extend science capability.

The initiative is closely aligned with emerging thinking on the development of an industry policy. Aerospace (along with agritech and digitech) has been identified as one of the sectors for collective government action. The space sector platform play will be incorporated into future activity under the policy.

The methane remote sensing satellite mission will put New Zealand researchers at the forefront of science that in the future could be integrated into the work of the New Zealand Agricultural Greenhouse Gas Research Centre or activity under the agricultural climate change research Budget bid.

2.3 Outcomes in a 5

Overall outcomes expected from this initiative

The following outcomes are expected in a 5 – 10 year time frame:

- New Zealand has successfully partnered in a greenhouse gas remote sensing mission and is leading the development of a second mission (with a different focus)
- New Zealand has a base level of science and engineering capability to provide a pipeline of talent for the space launch industry
- New Zealand is growing a 'new space' industry hub based on rapid development of small launcher and small satellite technologies
- New Zealand has developed niche capabilities, eg greenhouse remote sensing science
- Capabilities developed through the space sector are being applied to challenges such as increasing agricultural productivity, decarbonising the economy, and improved management of natural hazards
- New Zealand has a strong brand as a capable and globally responsible 'new space' actor

2.4 Implementation, Monitoring and Evaluation[3]

How will the initiative be delivered?

This initiative would be delivered by the New Zealand Space Agency through MBIE's Science System Investment and Performance Branch. The initiative involves different components requiring different delivery mechanisms. However, these are in line with MBIE's existing RS&I activities and functions. Delivery of the scholarships programme would be outsourced, potentially through an extension of existing arrangements with the Royal Society of New Zealand. Space mission support will require research contracts with New Zealand and overseas institutions. Any technical advisory support required would be built into space missions or other activities under this initiative.

s 9(2)(g)(i)

[3] This doesn't necessarily have to include a full implementation and evaluation plan, however the information provided must provide confidence that the proposal will be successfully delivered and there is a plan to ensure that the outcomes described are actually achieved.

	s 9(2)(g)(i) There are technical risks inherent in any space mission. Each mission would need to have an appropriate governance structure in place, and include experienced personnel. Processes, including for risk management, would be adapted from world-leading organisations such as NASA.
How will the implementation of the initiative be monitored?	All research funding contracts have reporting requirements in place. The reports may form milestones for payments and may be linked to external review/validation. Processes for designing and implementing space missions are necessarily highly structured and include regular check-in and reporting points. Data will be collected through the implementation of scholarships, including on student achievement and research impact. This will be reviewed on an ongoing basis and will inform decisions on future selection rounds.
Describe how the initiative will be evaluated	An impact evaluation will be scheduled at the three-year mark. The evaluation will be independent and will involve a contribution analysis focusing on skills development and economic impacts.

3. Wellbeing Impacts and Analysis

This section builds on the information provided in section 2 above and goes into further detail on the impacts, evidence and assumptions underpinning the intervention logic. It also asks that you demonstrate how your initiative will impact on wellbeing domains, the four capitals and risk and resilience.

The focus is on showing a strong narrative underpinned by evidence rather than monetisation of benefits and showing a positive return on investment. However, the use of the CBAx tool and monetisation is encouraged for key impacts with good evidence where it will strengthen the case for intervention.

Completion of this section is strictly limited to a maximum of three pages. This section helps the Treasury to assess and advise how the proposed initiative will impact the wellbeing of New Zealanders relative to the counterfactual. It may be provided to Ministers to support Budget prioritisation.

Impact summaries need to be framed against the three components of the Living Standards Framework, with supporting evidence where available:

- ***Wellbeing domains** – identify the value to New Zealand, magnitude and timeframe (up to 50 years) for impacts on the primary and (up to three) secondary domains targeted.*
- ***Four capitals** – identify the draw-downs, build-ups and/or transfers across the four capitals (physical, social, natural, human) resulting from funding the initiative.*
- ***Risk and resilience** – linking to the counterfactual and intervention logic, explain how the initiative adapts to or absorbs risk and/or how it maintains or builds resilience*

Please be aware that impacts or evidence are not mutually exclusive between wellbeing domains, capitals, and risk and resilience. They are interrelated cuts of the same information, we would expect that some answers may be duplicated.

3.1 Wellbeing domains – People's experience of wellbeing over time	
Identify and quantify how the initiative impacts on wellbeing domains	Please fill in Table 3.1 below. Impacts need to be grouped under the relevant domains, as provided in the key below. Use the relevant domains, ordering them from top to bottom according to which domain your initiative achieves the greatest impact in. This analysis must also capture any negative impacts. The wellbeing domains are outlined here for you to use in your table:

Civic engagement and governance	Jobs and earnings
Cultural identity	Knowledge and skills
Environment	Safety
Health	Social connections
Housing	Subjective wellbeing
Income and consumption	Time-use
	Other

3.1 Wellbeing domains – People's experience of wellbeing over time

Domains List domains, using the key above, where there is an impact. Order domains by magnitude of impact, i.e. largest impact domain first[4].	**Impact(s) description** Identify the impacts, with a separate line for each impact relating to a specific domain *Note you can identify multiple impacts for a particular domain. Delete/add rows as needed.*	**Who are affected?** Individuals/families/government/etc? Be as specific as possible. Are there distributional differences?	**Magnitude of impact** Relative to the counterfactual key assumptions, quantified to extent possible, and where possible monetised	**How big?** High/ Moderate/ Low, or where possible present value	**Realised** in <5 / 5-10 / 10+ years	**Evidence base** Nature of evidence and key references	**Evidence quality** High/ Medium/ Low
Knowledge and skills Primary	Lift in New Zealand space science and engineering capability	Current and prospective STEM students Universities and other research institutions, eg Centre for Space Science and Technology Established businesses, including those in adjacent industries that have potential 'spin in' technologies, eg robotics, sensors, advanced materials Space industry startups	New Zealand has a base level of science and engineering capability to provide a pipeline of talent for the space launch industry. New Zealand researchers and firms have advanced capabilities in niche areas of small launcher and small satellite technologies. Knowledge spillovers significantly extend national capability in priorities such as monitoring of natural hazards.	High	5-10 years	New Zealand is starting from a very low base, with few industry players. Assumptions about training needs have been reinforced through engagement on the New Zealand Space Strategy. In 2016, there were 435 students enrolled in aerospace engineering courses at bachelor level or above (MoE – Education Counts) *Economic Impact Analysis of the Development of a Rocket Industry in New Zealand* – Sapere 2016 – estimated spillover benefits between $160-$340 million of value add as a result of New Zealand industries having easier access to satellite technologies.	High
Jobs and earnings Secondary	High-skill, high-wage jobs are added to the New Zealand economy through Rocket Lab's expansion, new startups and investment by overseas firms.	University graduates Trained New Zealanders abroad looking to return Space sector firms	Rocket Lab and other space industry firms will be able to source most of their skilled labour from New Zealand. New Zealand will develop a hub for 'new space' activity based on rapid development of small launcher and small satellite technologies. New science jobs created in niche capability areas such as greenhouse gas remote sensing.	High	5-10 years	Rocket Lab has already grown to around 300 staff, the majority based in New Zealand. The global space industry was valued at USD339 billion in 2016; Bank of America Meryl Lynch estimates growth to USD2.7 trillion within 30 years. The Sapere 2016 report estimated that a rocket launch industry would contribute between $400-$1,150 million to the NZ (direct, indirect and induced impacts) and between $30-$110 million of value added in catalyst effects. The 2018 Australian space industry capability review estimated that the industry could add between 10,000 and 20,000 jobs to the Australian economy by 2030 (with an industry	Medium

[4] *Please note that in CFISnet, you will need to include the primary domain impacted, and up to two secondary domains impacted by the initiative. You can include as many domains as relevant in this table.*

						value of AUD10-12 billion. Evidence from the UK demonstrates that space economy employees are highly skilled (3 in 4 hold a higher education qualification) and highly productive (labour productivity of £140,000 – more than three times the national UK average of £46,000 (The Case for Space , London Economics 2015).	
Environment Secondary	Growth in environmental remote sensing expertise	Government –contribution to global GHG emissions initiatives Central and local government – resource management policies and decisions Businesses, particularly in primary industry and carbon intensive operations	New Zealand is an active participant in space applications for global efforts to address climate change. Knowledge spillovers extend national capabilities in natural resource management and primary sector productivity.	Moderate	5-10 years	*Earth Observation Technology in New Zealand* – Cawthron Institute 2018, soon to be posted on the NZ Earth observation colloquium website	High
Safety Secondary	Improved expertise in remote monitoring for public safety and national security	Government – security and emergency response agencies Local emergency response authorities CRIs and other research institutions Households	New Zealand has the capacity to develop space systems for national security, eg through maritime domain awareness, and to effectively collaborate with allies and friends. New Zealand more able to assist Pacific neighbours in managing security threats and exercising sovereignty. Improved capacity to monitor volcanoes, earthquakes and other natural hazards through remote sensing. New Zealand has better information to inform safer planning decisions, eg coastal erosion, land deformation.	Moderate	5-10 years	Strategic Defence Policy Statement 2018 Hazards research by GNS, NIWA and others, eg GNS presentation on landslide mapping Interagency engagement on space and security issues.	High
Cultural identity Secondary	Enhanced national pride	All New Zealanders	New Zealand has a strong global brand as a capable and responsible 'new space' actor. A new domestic narrative of New Zealand as a modern, sophisticated and capable nation with global impact.	Low	<5 years	There is significant anecdotal evidence of the inspirational impact of space activities. NASA's main Twitter account has nearly 30 million followers and Rocket Lab now has over 56,000 followers. The New Zealand NASA internships elicited over 200 applications for four places.	Low

3.2 Wellbeing capitals – Sustainability for future wellbeing

Wellbeing capitals

Please fill out the table below to demonstrate how your initiative may contribute positively, negatively or neutrally to the four capitals.

Capitals	Describe the impact and its magnitude	Realised in <5 / 5-10 / 10+ years
Financial/Physical	**Increase.** A significant net increase in financial capital is expected in the long term. A 2015 UK report estimated significant return from public space investments ,eg for Earth observation £2-£4 direct benefit plus £4-£12 spillover per £1 of public investment. In the short term, this initiative will lead to a decrease in financial capital as money is drawn down to fund the initiative. Some of this will result in an increase in physical capital in the form of research and space mission hardware, including satellites. The initiative will also result in further leveraging of R&D capital investment by overseas firms.	5-10 years. Initial gains will be seen within 5 years and fuller impacts within 10 years.
Human	**Increase.** This initiative is targeted at lifting levels of human capital within New Zealand by enhancing specialist training and providing research pathways to attract talented overseas scientists and engineers. We also expect to see human capital benefits to adjacent industries eg advanced materials, 3D printing. Greater application of Earth observation technologies will make an impact on New Zealand's low productivity challenges.	<5 years. Some elements of the initiative, eg short term internships, will result in rapid human capital gains.
Natural	**Maintain.** Earth observation from space is playing an increasingly important role in understanding climate science and other natural systems, and this enables better- informed economic and environmental policies. This first space mission under this initiative will focus on greenhouse gas emissions. There is significant scope to increase the application of satellite remote sensing data in New Zealand, eg monitoring forest growth and disease detection, water volume and quality estimates, and monitoring fishing in New Zealand's EEZ.	10+ years
Social	**Increase** Social capital is not explicitly targeted in this initiative. Space does, however, have a unique ability to inspire a nation and increase a national sense of confidence and wellbeing.	<5 years

3.3 Risk and resilience narrative	
Does the initiative respond to or build resilience?	Modern societies are heavily dependent on space systems in areas such as navigation, weather and climate forecasting, communications, and national security. New Zealand is however, entirely dependent on space assets owned and operated by overseas entities and currently does not have the capability to conduct national space missions. This initiative is designed to build the capability required to develop and operate indigenous space systems or to contribute meaningfully to collaborations with partners. An enhanced skill base in Earth observation technologies will enhance risk management capability, eg natural hazard mapping and modelling, climate forecasting, intelligence gathering on security threats. The skills capability developed through this initiative will assist in advancing Defence maritime surveillance capability that will complement the P8-A investment – to be articulated in the Defence Capability Plan. The initiative will also provide an opportunity to diversify sources of export earnings (with potentially a net positive environmental impact).

4. Costing understanding and options

This section will provide further information on the costs of delivering the initiative and options for scaling and phasing to support assessment, prioritisation and decision-making.

4.1 Detailed funding breakdown

Please provide a breakdown of the costs of this initiative

($m)	2019/20	2020/21	2021/22	2022/23	Component Total
Capital costs	2	-	-	-	2
Scholarships and Training	1	2	2	3	8
Missions and Programmes	3	8	7	7	25
Depreciation and capital charge		0.3	0.3	0.3	0.9
Total	6	10.3	9.3	10.3	35.9

Ideally, this initiative should be a **multi-year appropriation**. Space missions – the key component of this initiative – carry inherent technical and operational risks. A multi-year appropriation would provide the flexibility to adjust expenditure in response to robust project management decisions.

The budget includes up-front capital costs for satellite testing and mission control equipment. The assumption is that this would be set up in partnership with an existing institution and would not require the purchase of land or buildings.

The initial greenhouse gas mission is planned for launch in 2021 and expenditure rises in year 2 to account for satellite launch costs. The programme would involve multiple missions running simultaneously but at different stages of the mission cycle.

Training costs are based on an estimate of $100,000 per annum per scholarship and $25,000 per internship (including tuition; travel, accommodation and allowances; and management contract costs).

4.2 Options for scaling and phasing

Scaling, phasing or deferring - including 75% and 50% scenarios

If this initiative were to be funded at 75%, the scholarships component would be reduced by about half and the mission and programmes component would be reduced by about $5m. In a 50% scenario, the scholarships and training component would be reduced to a minimal level, and the focus would be on the missions component. The capital costs are unlikely to be scalable, but in any case this is a small part of the total budget.

A scaled approach would slow progress towards the R&D 2% of GDP target due to lower growth in GERD, and in BERD given that space sector R&D capability is a pre-requisite for both domestic firms and potential aerospace industry investors.

A key risk of a scaled approach would involve losing opportunities to leverage off Rocket Lab's operations in New Zealand and to build greater competitive resilience. These opportunities include

	spin out companies and additional foreign investment in the space sector. s 9(2)(g)(i) [redacted]

5. Collaboration

This section provides information on how agencies have engaged both within and outside of their own departments in the development of this initiative. Cross-agency and cross-portfolio collaboration are both important in this context. Please ensure this section is clear and succinct, and no longer than one page.

5.1 Collaboration and evidence	
What type of cross-agency and/or cross-portfolio initiative is this?	This is a single agency (MBIE), single portfolio (RS&I) bid with cross-portfolio and cross-agency relationships and implications.
Agencies and Ministers that have been engaged in initiative development	The Minister of Research, Science and Innovation is the lead minister for the bid; the funding would sit within Vote Business, Science and Innovation. The funding would also deliver against space policy priorities with the portfolio of the Minister for Economic Development. The Minister for Climate Change has been briefed on preliminary consultations on a greenhouse gas remote sensing mission that could be an early activity under this initiative. The initiative has emerged from several cross-agency processes, notably: • consultations on a New Zealand Space Strategy • standing cross-agency meetings on regulatory and risk issues • collaboration with LINZ and MfE (and other parties) on an Earth observation conference and follow up actions • consultation with MFAT and MfE on international climate change engagement • consultation with the Defence Technology Agency on space sector priorities. The initiative has been informed by ongoing discussions with the key organisations in the sector: University of Auckland, University of Canterbury, Auckland University of Technology, Rocket Lab, Venture Southland, Centre for Space Science and Technology, GNS, Manaaki Whenua Landcare Research and NIWA. This has focused on addressing the current capability gaps and opportunities. The initiative also responds to engagements on collaboration opportunities with overseas partners, notably DLR, ESA, NASA, and private sector firms.
Impact of cross-agency collaboration	Interagency consultations have confirmed that rapid development of fundamental domestic capability will help underpin a variety of sector specific interests in space. They have also confirmed the value in having an environment or climate change focused mission as an early deliverable.
Risks and challenges	Challenges may emerge when deciding on the focus of missions funded under the initiative, ie which New Zealand interests should take priority. Even within a particular domain, there will be trade-offs required in regard to satellite instrument capability. Some of the specific decisions are likely to be made by research and industry participants through government taking a challenge approach to mission design.