Cementing Australia as the leader in advanced technology

Developing the Australian Advanced Technology and Resources Management Fund

Pre Budget Submission

2020-21

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Foreword

A roadmap to deliver Australia's new advanced technology industry

Titomic Limited is a proud Australian SME, at the forefront of additive manufacturing and advanced technology solutions for clients around the world.

More than this; we are inspired to help harness our technology discoveries, strong academic, science and global industry networks, to help deliver the Government's important agenda of creating a new advanced technology industry for Australia.

The world's economic development is in a tedious phase of uncertainty as we shift from many traditional industries and processes, into a new world of advanced digital technologies and developments that require very different resources and skill sets to those currently being offered.

Globally, Australia is recognised for its resources and early-stage technologies. However, it is widely accepted, that Australia only captures a very small part of the returns within the entire mining and manufacturing value chain from its natural resources. Right now, too many early stage technologies ultimately must shift overseas to truly be recognised, accepted and properly resourced and funded for success.

Within Australia, there are many siloed industries, financial support initiatives and human resource skill sets that should, and can, better collaborate and co-ordinate to leverage the scarce resources available.

Right now, Australia is short changing itself and precious taxpayer R&D funds are being spent on worthy but repetitive projects that are not delivering the large scale, nation building endeavours we know are possible and can be realised within the next two years.

This pre budget submission identifies the rationale for a national blueprint to map out the overarching opportunity for Australian companies and governments to band together and harness this chance to become a truly dominant international player.

Our initiative to design a roadmap and implementation strategy, through the **Australian Advanced Technology & Resources Management Fund,** will see significant advancements across Higher Education, resource management, mining, emerging advanced technologies, rare earth industry

development, space industry development, plastic repurposing, start-up and early-stage SMEs, grants and Government funding, and mostly importantly jobs.

In a similar vein, in which the Government has achieved enormous success in breaking down the silos between medical researchers and front-line health professionals with its globally respected and well-funded Medical Research Future Fund, we believe a similar strategic approach is required for our new technology and advanced manufacturing sector.

We also know the returns on this investment will significant both in terms of sovereign independence, economic prosperity for our country and job security for the next generation of young Australians.

For example: if we can build a sustainable value chain around Australia's access to critical metals, resulting in the export of higher valued product, we will dramatically enhance Australia's sovereign capability ensuring that the resources last for centuries to come. We know Australia could have generated $13.5 billion in revenue, in 2018 alone, by adding just one more stage in production to the mineral sands prior to export.

We look forward to working with the Australian Government to show you how Titomic can help build a truly global-leading advanced technology industries employing thousands of skilled, industry-ready employees.

We will demonstrate how we are capable of pushing Australia forward as a genuinely transformation nation to ensure our children, for generations to come, not only have steady skilled employment, but that the country in which they live has implemented sustainable industry and resource management practises for the future.

We commit this pre budget submission for your consideration and look forward to working with the Government to achieve its goals of making Australia a true global leader in this exciting and yet to be fully realised sector.

Jeffrey Lang
Managing Director
TITOMIC LIMITED

Executive Summary

Our proposal is to work with Australian governments, scientists and key global industry leaders to develop a:

- Mineral Resource Management Plan;
- an Australian Advanced Technology Fund; and to
- create a new value chain surrounding waste management and material repurpose

If implemented, as recommended, this blueprint, will by the end of 2022, deliver its key objectives of achieving the following vision spaning three key market segments:

Mineral Resource Management Plan:

- Capture increased return from mineral resource value-chain for Australian mining companies;

- Create new industries surrounding Australia's large Rare-earth and Titanium resources;

- Work with native title land holders through existing relationships with Aboriginal elders to unlock unutilised pockets of Australian resources (in particular Titanium) on their land ensuring value is maximised and returned to the traditional landowners; and

- Improve mining industry engagement and collaboration

We know Australia could have generated $13.5 Billion in revenue in 2018 alone, by adding just one more stage in production to the mineral sands prior to export. There is an enormous untapped potential in the research earths and metals of military importance that can, and must, be realised.

Australian Advanced Technology Fund

- Ensure Industry's adoption of STEM within a Digital 4.0 environment
- Introduce a sustainable framework for SME's to collaborate and pool resources to harness symbiotic growth instead of competing for the same resources in competition.

Creation of Value Chain surrounding Waste Management and material repurpose

- Create framework for the lifecycle management of plastic and other industry and household waste

- Develop new value add industries that will cement Australia as a leader in the repurposement of waste for biofuels and other green energy production capabilities.

We know we can redefine Australia's global branding from selling dirt and beaches and great start-up ideas which can be acquired, to being a land of highly skilled individuals, building world leading advanced digital technology industries to capture more of an industries intrinsic vertical value.

This would build on the work undertaken by Austrade to develop Australia's 'nation brand'. It would make Australia a destination high tech and advanced manufacturing hub for international investors across the sectors of space, rare earths, defence, environment and mining. Our job-ready, university and TAFE graduates will be in high demand and our children (and their children) will be assured of strong and successful futures in the industries of tomorrow.

In order to achieve our collective mission of designing a wholistic industry approach across all of these areas, by the end of 2022, we seek the Australian Government's support to contribute $20 million to these initiative over the next 2-years, being $10 million annually.

These funds will be invested into a Government owned Australian Advanced Technology & Resources Management Fund a board of experienced industry leaders such as Titomic. We anticipate that the fund will become cost neutral for the Government over time as industry participants can be charged a membership fee.

Background – a call to arms

Australia's geographic isolation creates a unique cultural predisposition of siloed thinking amongst the advocates of government and commerce that has not necessarily served our best interests for economic independence.

This has traditionally been due to the raw, unrefined commodities traded predominately with China under the scrutiny of UK and the US.

How can Australia instead propagate its cultural identity and independence to the rest of the world that represents the neutrality of our pioneering spirit and reflects our unique approach to solving problems?

Australia needs to move its mindset from selling dirt and fossils at low value and to see and believe we are the most important player for the future sustainability resource management to the world and humanity.

Australia has the potential to be the global leader in advance technology by offering a unique value chains that is desired by the rest of the world and in respect of our neutrality.

Increasingly, we see evidence and acknowledgement by the UN that the global economy is exposed to nearly $1.2 trillion in potential losses over the next 15 years relative to climate-related risks to companies.

Australia is in a precarious position due to its significant sovereign dependency on export of coal, LNG, mineral resources and Agriculture where greater transparency is urgently needed to create sustainable value chains for Australia future strategic growth sustainability.

Global financial firms responsible for assets in excess of $118 trillion are evaluating their investments in fossil fuels and mining resources and are now diversifying their investments towards sustainable green advanced technology assets.

The recent acknowledgement from the Network for Greening the Financial System (NGFS), a group of 36 central banks and supervisors, that “climate-related risks are a source of financial risk [and it] falls squarely within the mandates of central banks and supervisors to ensure the financial system is resilient to these risks.

Key strategies are urgently needed for the Federal Government to foster in a resilient future for Australia that secures sustainable management of our natural assets by creating new value chains that strategically positions Australia as the global leader in advancing technology as a viable solution to economic independence.

We believe these are the right strategies for 2022 and beyond.

The Proposal – a three-pronged approach

1) Mineral Resource Management Plan

Titanium is the fourth most abundant mineral resource for structural metal after aluminium, iron and magnesium. It presents in the Earth's crust at a level of about 0.6%.

According to U.S. Geological Survey (USGS,2019), Australia is estimated to have 29 million tonnes rutile (TiO_2) reserves (47% of the world total) and 250 million tonnes ilmenite ($FeTiO_3$) reserves (28% of the world total).

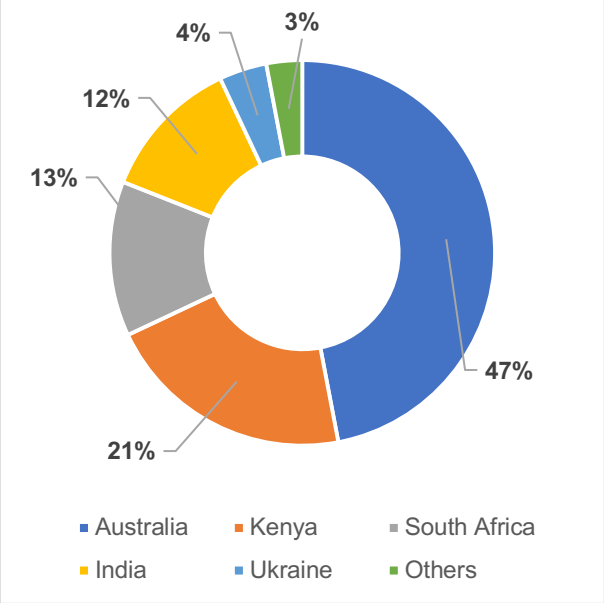


Figure 1 The total world reserves of ilmenite

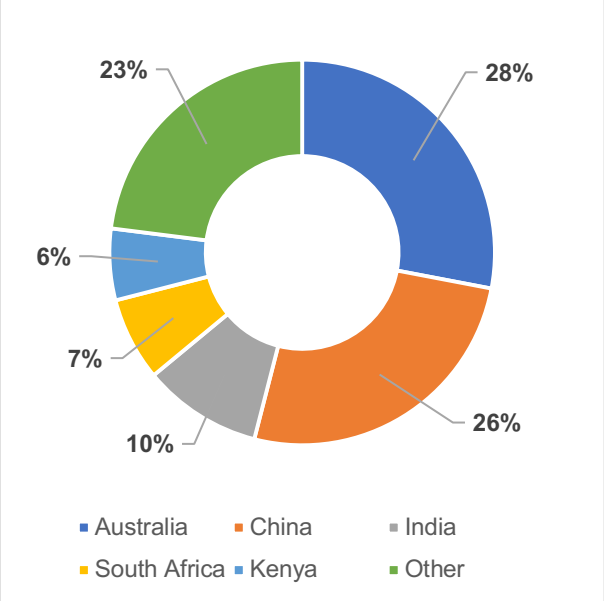
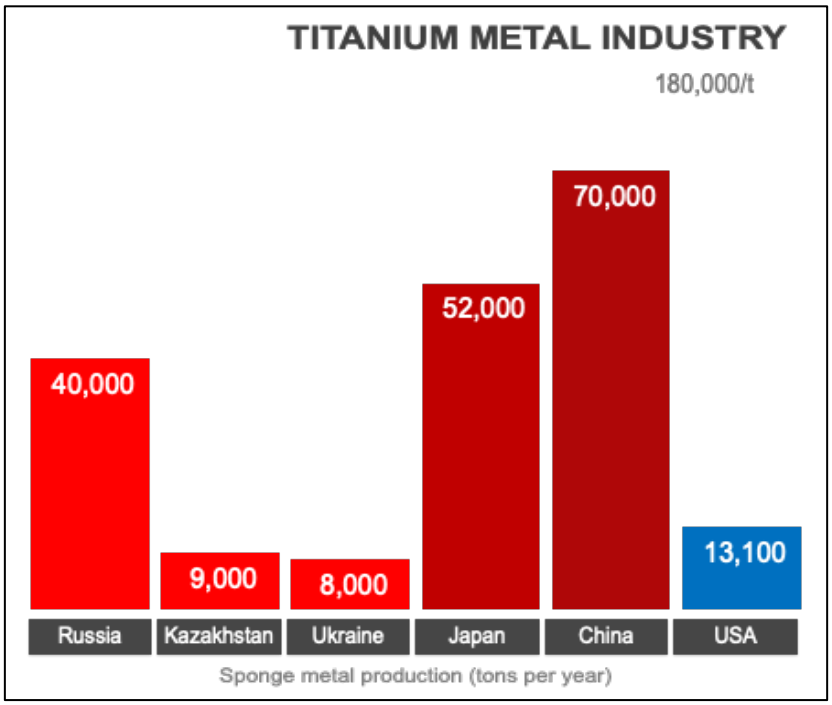


Figure 2 The total world reserves of rutile

The issue

Despite having the largest global reserve feedstock for Titanium, Australia does not currently produce Titanium in any metal form and only exports mineral resources. The titanium metal market is currently dominated by Russia, Ukraine, Kazakhstan, Japan, and China.



In 2018, Australia exported 1.35 million tonnes of titanium mineral sands, the precursor feedstock to produce Titanium, which had a total export value of just $535 million.

Thus, securing supply chain of titanium and other critical metals is a key requirement for building Australia's defence and aerospace sovereign industrial capabilities but despite having the largest natural reserves in the world, Australia only exports the raw material at a factual of its finished-product sale value and accordingly is not utilise the full benefits of abundant natural resources.

The Titanium mineral sand feedstock is exported now to produce titanium dioxide being the white additive colouring pigment found in many products, foods and paints.

Whilst the mining industry is one of the main contributors to Australian economy, at the current rate of growth of the titanium dioxide market being at a CAGR of 5.8%, Australia will run out of Titanium feedstock reserves altogether within next 95 years without having harnessed the true value of the resource as commercial Titanium.

The solution

The global titanium metal production, in its primary form of sponge, has a total global market capacity currently of just 180,000 tones which due to the high demand for Titanium is generating as much as $1.8 Billion ($1,800,000,000), or 10,000 per tonne, in revenue per annuum.

Taking these revenue metrics from just 180,000 tonnes, should we take Australia's total 2018 mineral Titanium feedstock sand export capacity of 1.35 million tonnes at the same pricing, this could have generated $13.5 Billion in revenue by adding just one more stage in production to the mineral sands prior to export. This means in just 2018 alone the Australian industry missed out on $12.97 Billion.

Life Cycle Stage	Ilmenite	Rutile	Sponge	Ingot	Wrought	Powder	Final Parts
Country	Australia Exports		Russia, China, Kazakhstan, Ukraine, Japan, USA			Five Eyes	Five Eyes
Price per kilogram ($ kg)	$ 0.17	$ 0.64	$ 9.84	$ 16.2	$ 47.8	$ 200	$1,500

Comparison based on Australia's 2018 Mineral Sand Exports of 1.35 Million tonnes						
Revenue achievable from sale of 1.35M tonnes	$535M	$13.3B	$21.9B	$64.5B	$270B	$2.25T
Revenue actually received from on 1.35M tonnes	($535M)	($535M)	($535M)	($535M)	($535M)	($535M)
Deemed Value lost by Australian mining industry	$0	($12.8B)	($21.3B)	($64.0B)	($269B)	($2.24T)

The above table not only shows the revenue potential being lost by the Australian mining industry from exporting base product in comparison to just one further stage added to the value chain prior to export.

Build a sustainable value chain around Australia's access to critical metals resulting in the export of a much higher valued product, will dramatically enhance Australia's sovereign capability ensuring that the resources last for centuries to come.

Significant parcels of native title land have been exploited by large mining companies who, even themselves, have not captured the true value locked up and contained within these mineral reserves.

Currently, more mineral rich resource land is held by native title owners than government owned crown land. Through existing and trusted traditional owner relationships, we will seek to unlock these parcels of land and return true value back to the traditional owners to the benefit of them and their communities.

This new increased value chain will also develop an entirely new capability for many Australian industries which will ultimately lead to better living standards within these communities, improved resources and education, many more local jobs, higher skilled local labour leading to higher employment in their traditionally higher unemployment and lower skilled labour areas. It will empower our first nation people and it will be nation changing - economically and socially.

We know this is a significant focus of the Morrison Government and we stand ready to help deliver on its policy objectives.

Turbocharging industry's adoption of STEM within a Digital 4.0 environment

The issue

Are we ready?

The transition to Industry 4.0 is well underway in many countries - being helped, in no small part, by governments funding national programs to promote the uptake of additive manufacturing.

These organisations offer funding, collaboration opportunities and other financial and commercial incentives to promising additive manufacturing businesses. In many countries, for the most part, the programs work with established large organisations to help smaller organisations enter the market through collaborative efforts.

Deloitte's 2020 annual survey on business's preparedness for Industry 4.0[1] highlighted the need for a sharper focus on the uptake of transformational technologies. In surveying over 2000 executives across 19 countries, it was found that two thirds of respondents have no formal strategies or are taking ad-hoc approaches to Industry 4.0 advancements.

They also revealed that only 10% of executives had long term strategies to leverage new Industry 4.0 technologies.

This highlights the importance of government and industry groups promoting collaboration and consultation in preparing for a transition to Industry 4.0. In a study of Australian business preparedness for Industry 4.0, undertaken by PWC,[2] the transition to digitalisation and smart automation was poised to add 14% or $1.5T to global GDP gains by 2030.

In order to take advantage of these gains, business and workforce transformation is essential. This will ultimately lend on the labour force sectors of education and training to deliver properly skilled people we will need for this exciting but challenging phase.

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[1] Deloitte 2020 *Leadership in the Fourth Industrial Revolution: Faces of progress*

2

Transforming Australian Manufacturing: Preparing businesses and workplaces for Industry 4.0

https://www.pwc.com.au/education/industry-proposal-13may2019.pdf

The PWC report recommends an urgent 'call to action' to understand why more must be invested into workforces, research and innovation to thrive in the next industrial revolution.
If Australian business is not able to embrace a transition to advanced manufacturing through Industry 4.0, Australia will miss out on the significant GDP growth gains it otherwise could have, or we expect the country to achieve.

Overall recommendations from the PWC report identified a need to transition through a number of sectors including:

a) an increased need for collaboration between businesses,
b) an increased need for collaboration between businesses and governments,
c) increased education and training in order to develop the workforce to be ready for Industry 4.0.

Globally, many countries have designed and implement dedicated national programs focussed purely on transitioning traditional manufacturing processes to advanced manufacturing and Industry 4.0. The leading countries undertaking such initiatives in this area are the USA, Canada, UK and Singapore.

The organisations in each of these countries promote collaboration, offer financial incentives and administer industry projects which enable the growth in uptake of AM practices. Although funding amounts and methods differ, all of the organisations receive significant amounts of funding from their governments, showing how important this area of development is for the future economies of these countries.

The solution

Intimately, Australian industry needs such a plan now to stay relevant in, and re-enter, the competitive global market:

- Academic institutes need to return on quality education focused deliverables, not profits;
- educate students proficiently such that they are industry ready from day one;
- fill industry skill gaps with newly trained students to champion transition;
- retain Australian-educated local and foreign students to increase the skilled labour workforce; and
- take advantage of the significant opportunity Australia has to own the industry 4.0 digital advanced technology and manufacturing sectors implemented using smart factory processes.

Appendix A has a detailed snapshot of initiative undertaken overseas.

Titomic would work with our academic partners and industry colleagues to review of the gaps and barriers and present a roadmap to develop the Australian Advanced Technology Fund.

This will – by 2020:

- Establish sustainable funding channels through investment, grants & tax incentives to truly support emerging technologies and companies through their foundation set-up years;

- Create incubator hubs to foster co-development and collaboration between advanced technologies to mature technology advancements faster

- Develop practical advanced technology curriculum programs for students to propagate a workforce of highly skilled digital robotics, AI and material science engineers (Industry 4.0);

- Assess and redesign university curriculums to ensure students receive fundamental basic lateral-thinking and concept training to break a current pattern of one-dimensional thinking;

- Reinvigorate Universities and Education Institutes to be skill, knowledge and industry focused outcome instead of the profit conglomerates they have become focused on today.

- Better align the student academic outcomes to the needs of industry to enable students to truly be job-ready when completing higher-education

- Develop career and support pathways to retain the significant number of international students studying in Australia who after completion of their education cannot find a job in an industry within their field of study, or who choose to move overseas to explore job opportunities.

Creation of Value Chain surrounding Waste Management and material repurpose

The issue

What will Australia do with it's going commercial, household and industrial waste, particularly plastics? bury it, burn it? or repurpose it?

Let's face it, selling our waste to China to burn was never really a true answer to our waste and recycling of plastics but now as China has now closed its boarders to accepting Australia's waste, the problem surrounding what to do with our waste, particularly plastics, is mounting daily.

There Municipalities are struggling to find avenues to process and dispose of household waste from recycling bins particularly in light of the collapse of many recycling plants who previously used to purchase these materials.
These companies collapsed because whilst they could repurpose or reuse many of the materials, it was not economically viable as there was no market demand for the down-stream output product of these repurposed materials.

There needs to be a fundamental mentality shift within all of Australia's stakeholders from recycling, to repurposing waste products for which strong down-stream value chains can be created.

The solution

Titomic can work with the Government to create a new Value Chain surrounding the repurposing of waste management and other materials.

- Create framework for the lifecycle management of plastic and other industry and household waste. This will lead to genuine waste management solutions for municipalities and their rate payers. Currently municipalities are struggling to find a solution to their problem of what to do with the waste.

- Develop new early-stage vortex milling processes to break waste down into nano particle powder elements for repurposing; By alleviating waste management issues through the repurposing of waste by breaking it down to its nano-powder state, 3D metal, plastic, and fibre printing technologies can utilise these nano-powder feedstocks to product new

products. This closes the entire value chain loop of a product life-cycle from powder, to product, to powder to product and so on.

- Create industry driven feedstock value chain for nano-particle milled waste utilising automated robotic plastic and metal additive manufacturing printing technologies within a digital 4.0 smart factory facilities;

- Repurpose waste for biofuels and other green energy production capabilities.

A snapshot of two of these key technologies is outlined in Appendix B.

Recommendation

We recommend the Australian Government to work with Titomic to design and establish the **Australian Advanced Technology Fund and Mineral Resource Management Plan**.

We estimate the cost to the Government would be $20 million to both of these initiative over the next two years.

These initial $10m of funds for 20-21 would go into the sovereign **Australian Advanced Technology Fund**, co-ordinated and managed by a Government-held trust with Titomic and other industry leaders as key board advisers.

The fund could be cost neutral by charging annual memberships for industry participants and then award co-contribution grants for projects based on their submissions.

Conclusion

This strategy underscores Australia's new confidence and readiness to take risks, define big, long-term goals, and have the audacity to do it the Aussie way and have a go. This strategy is a hand up for industry, not a hand-out.

Titomic's strategic vision roadmap and commercial endeavours has defined the whole commercial value chain of Australia's 280M tonnes of Titanium mineral sands "From Ore to More" and gained the interest of other country Governments and major industries.

It also highlights that global leading advanced technologies created by co-operative partnership between research (CSIRO) and Industry (Titomic) creates a diverse skillset symbiosis that is both respected and accepted as representative of Australian sovereign capability.

In establishing this **Australian Advanced Technology Fund and Mineral Resource Management Plan**, the Australian government may also gain access to seek sustaining funding from the Task Force on Climate-related Financial Disclosures (TCFD) which has International held funding available in the $Trillions.

https://www.fsb-tcfd.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf

This fund will also complement the Government's recently announced development of a $500m Business Growth Fund for SMEs that is being funded by co contributions of the major banks, superannuation companies and the government.[3] This in turn follows the success of the United Kingdom's Business Growth Fund, which has now invested $2.7 billion in a range of sectors across the economy.

It could also replicate the success of the USD 100 trillion asset funds[4] being redistributed from mining and oil and gas to green advanced technology.

The key difference and opportunity with the **Australian Advanced Technology Fund and Mineral Resource Management Plan** is that it will:

1. Create the opportunity for Australia to build a sovereign wealth fund around advancing green technology and access the global asset funds;
2. Provide a strategic plan for sustainable management of Australia's abundant natural resources and
3. Develop and implement value chains around Australia's key export trading commodities by utilising advanced technologies.

Titomic commits this pre budget submission to the government and we look forward to working with it to create a strong and prosperous future for our children, our communities, our workforce and the industries of the future.

[3] https://treasury.gov.au/small-business/bgf

[4] https://www.fsb-tcfd.org/wp-content/uploads/2019/06/2019-TCFD-Status-Report-FINAL-053119.pdf

About Titomic

Titomic Limited (ASX:TTT), headquartered in Melbourne, Australia, is a pioneer in advanced manufacturing. The company's proprietary system of robotics, patented process and material science produce goods at industrial scale, faster and cheaper. The Titomic Kinetic Fusion™ process creates superior products at lowered production costs, using less resources for a more sustainable future. Multiple robots can be utilised to build larger parts, competing with traditional manufacturing solutions for industries such as aerospace and defence, sporting goods, medical, automotive, industrial equipment, construction and marine.

Appendix A

Initiatives undertaken overseas:

USA

America Makes is the USA's national accelerator for additive manufacturing and 3D printing. It was established in 2012 and is the flagship organisation for Manufacturing USA, the National Network for Manufacturing Innovation. America Makes is managed by the National Center for Defense Manufacturing and Machining and in 2018 received a budget of $115M.

The organisation is structured as a public-private partnership with member organisations including industry, academia, government, non-government agencies, and workforce and economic development resources. The goal of the organisation is to increase the USA's global manufacturing competitiveness.

America Makes enables collaboration between AM organisations through several projects focussed on elements within the overall roadmap. In addition, there are challenges available to undertake which could see participants being awarded large grants to develop their solutions.
https://www.americamakes.us/about/

Canada

The government of Canada has funded many programs which promote the progression of the manufacturing industry. The country has focussed mainly on the development of materials production for Additive Manufacturing, with metal powders production appearing to be a high priority. This sets up the country's manufacturing industry with a secure local supply chain for advanced materials.

The Quebec Economic Development Program supports the development and economic diversification of regions and helps them seize promising economic development opportunities for the future. The organisation offers interest free loans to companies for up to 50% of the cost of equipment, inventory, long term assets, real estate, short term assets and other eligible items.

Companies involved in advanced manufacturing in the country include AP&C (GE), PyroGenesis and Tekna, all of which have benefited from the Governments of Canada and Quebec as funding

partners. Quebec appears to fund the organisations through the Quebec Economic Development Program.

For example, in 2018, Tekna received investments from the Governments' of Canada and Quebec respectively. This investment came as a part of a project worth over $100M. The amount contributed by the governments was funded more than one fifth of the total project value.

United Kingdom

The UK Government has a number of programs which it has funded with the goal of promoting the adoption of additive manufacturing. The Department for Business, Energy and Industrial Strategy funds a non-governmental body known as UK Research and Innovation, which in turn funds Innovate UK which funds a number of AM related R&D projects. Since its inception in 2007 Innovate UK has invested £2.5B into projects worth £4.3B.
In addition, the UK Government has also promoted AM through AM UK (Additive Manufacturing UK) an independent government supported collaboration with an aim to promote acceptance of additive manufacturing in the UK through workshops and industry consultation. The organisation is led by representatives from leading manufacturing companies.

Through a process of industry consultation AM UK has come up with a series of recommendations for the manufacturing industry to collaboratively promote AM and to work towards a digitalisation of industry. There are further recommendations made in the specific areas of design, materials and processes, inspection, IP, skills, supply chain, and implementation.

Outside of formal organisations the UK government has funded projects such as the Advanced Manufacturing Supply Chain Initiative (AMSCI) and the CASCADE project. The Cascade project was run by a consortium of 11 companies with a view to develop metal powders for AM and refine AM processes. These advanced manufacturing projects received over £235M from the UK government and show the ongoing commitment by this government to industrial transformation.

Singapore

The Singaporean government has a number of organisations operating under the Ministry of Trade and Industry, which are helping to promote a move to advanced manufacturing.

The Singapore Economic Development Board offers grants, and tax assistance to companies which they hope to attract to the country. A*STAR ($25.2B from 2015 onwards) is a research organisation

set up to bring scientific discoveries to market through spinning off research into commercially successful businesses. SIMTech is an organisation focused on collaboration with industry to improve skills and increase the value of manufacturing and falls under A*STAR.

Finally, NAMIC is an AM focussed organisation focussing on accelerating AM startups' development. NAMIC has collaborated with a great number of start-up companies involved in AM, having reported that 1700 companies have been engaged and 222 projects being initiated.

Appendix B

Creation of Value Chain surrounding Waste Management and material repurpose

There are two separate advanced technologies that Titomic is developing with other alliance partners and can achieve some extraordinary outcomes:

1. Converting Waste to Combustible Gas
2. The Resonant Vortex Milling

1. Converting Waste to Combustible Gas

   This new Australian technology creates nearly 668,000 litres of natural gas per hour from approximately 300kg of black or brown coal mixed with a proprietary fuel mix and converted in a proprietary vapour chamber.

   With ZERO CARBON EMISSIONS!

   The mix can also include granulated plastic waste and rubber tyres offering the opportunity to dispose of this global waste problem without any detrimental effect to the environment. Waste to energy through repurposing not recycling.

   With ZERO CARBON EMISSIONS!

   The fuel mix has the ability to be modified for use in turbines and reciprocating engine drivers used in power plants.

   Cost of production for the fuel mix is significantly less than current alternatives and requires minimal infrastructure.

   The process takes Black coal micronizes it mixes it with a fuel source (IP) then placing into a proprietary vapour chamber and converting it into gas. The output is a combination of Hydrogen, Methane and Oxygen.

A secondary proprietary process also exists to transfer brown coal to a black coal alternative to use in the same process. The brown coal is mixed with a combination of wood chips and an IP food source and biological agent.

2. The Resonant Vortex Milling

The resonant vortex mill is a new technology process for the contact-free milling of materials carried out by using an air vortex system which enables the milling of any waste material, from liquids to diamonds.

The destruction of materials of any hardness is performed by creating different zones of pressure gradients within the vortex mill pressurised up to hundreds of thousands of atmospheres. These materials break down as they go through the vortex milling process and the particles resonate and collide to continue breaking down to nano-particle level.

The second stage in the system is the resonance milling which is a system which generates wave oscillations with a frequency range from sonic to supersonic (100 MHz and above)

within the mill. These vibrations determine different frequencies for different materials being milled and is able to separate the materials into different outputs based on the resonance feedback that particle provides from the vibrations. This mechanism is able to produce micronization measured in hundredths and thousandths parts of a micron (0.01-0.001 mm).

The third stage within the milling process is the impact vortex mill for the collision of particles. In the resonant vortex mill, the colliding of material particles to break them down to smaller particle size.

The resonant and vortex milling process is a gas-dynamic mill where the multicascade adiabatic resonant and impact milling is realised at various speeds for impact and destruction. For torsion (blast) mills, it is typical to use compressed air at pressures of 0.7-1.4 MPa, whereas a vortex mill is capable of reaching 0.2-0.6 MPa which substantially decreases running cost and makes possible to obtain fine powders outputs which can be reused using 3D Printing.