University of Melbourne response

Make it Happen

Australian Government's Modern Manufacturing Strategy

November 2020

Executive Summary

The University of Melbourne welcomes the opportunity to respond to *Make it Happen: The Australian Government's Modern Manufacturing Strategy* (the Strategy). Manufacturing remains a key element of Australia's economy, and will play an important role in the economic recovery from the COVID-19 recession. The disruption caused by the pandemic represents an opportunity to reset the strategic approach taken to Australia's manufacturing sector.

As a teaching and research institution, the University of Melbourne is well-positioned to engage with the issues raised in the Strategy. The University's 10-year strategy, Advancing Melbourne 2030, was launched earlier this year. Advancing Melbourne 2030 includes a framework for tackling society's challenges through supporting discovery, innovative and translational research, growing university-industry partnerships and providing a world-class teaching experience for students. The themes of Advancing Melbourne 2030 underpin the University's response to the Government's Modern Manufacturing Strategy.

The Strategy rightly recognises that Australia is best positioned as a high-value manufacturing economy: Australian businesses typically cannot compete with low value manufacturing entities in other economies. The University of Melbourne suggests that the support measures initiated by the Strategy should include the following elements:

- Initiatives that emphasise products and services that incorporate highly innovation design or engineering;
- Initiatives that leverage "new to the world" scientific or technologic content;
- Initiatives that depend on a high degree of complexity and/or technology integration;
- Initiatives that leverage a niche for Australian products and services in global value chains;
- Initiatives to increase the capabilities of the Australian workforce at all levels through broad-based educational improvements.
- Initiatives that address the impact that manufacturing has on Australia's carbon emissions.

The following comments address each of the six national manufacturing priorities identified in the Strategy, highlighting how the above elements may be integrated into the approach to supporting those priority sectors.

The University of Melbourne looks forward to continuing to work with the Australian Government to help advance Australian manufacturing.

For further information, or to discuss the submission, Professor Mark Hargreaves, Pro Vice-Chancellor (Research Collaboration & Partnerships) can be contacted at dvc-research@unimelb.edu.au or on (03) 8344 3238.

Recommendations

1. Resources Technology and Critical Minerals Processing

The University of Melbourne recommends that the Australian Government:

- Ensure that the Modern Manufacturing Strategy include a focus on:
  - Hydrometallurgy and pyrometallurgy as innovative production processes for minerals.
  - Processing of lithium and rare earth metals.
  - Innovation in process technologies
  - Initiatives to add more value to raw materials
- Commit to a flexible education and training system that enables upskilling and reskilling opportunities to add to the agility of the sector workforce.
- Address the barriers to research translation.

2. Food and Beverage

The University of Melbourne recommends that the Australian Government:

- Ensure that the Modern Manufacturing Strategy addresses all parts of the food and beverage supply chain, and that it is sensitive to the differences between sub-sectors.
- Promotes research collaboration between universities and food and beverage businesses.
- Commit to measures to support the food and beverage industry to attract and retain a high-skilled workforce in technical and managerial roles.
- Ensure that the Modern Manufacturing Strategy recognise the challenges that climate change poses for Australia's food and beverage industry.
- Support supply chain innovation.

3. Medical Products

The University of Melbourne recommends that the Australian Government:

- Commit to measures to grow Australia's Medtech and Pharma sector.
- Ensure that the Strategy recognises the importance of enhancing sovereign capability, particularly in active pharmaceutical ingredients (APIs).
- Commit to upgrades that address the limitations in Australia's current stock of medical product facilities.
- Support capacity building through targeted support for education and training programs.
- Ensure that the Strategy recognises the benefits of Continuous flow chemical synthesis.
- Ensure that the Strategy recognises the benefits of Additive manufacturing.
- Provide targeted support for research translation.
- Address the inhibitors to growth in personalised implants and surgeries.
- Address the lack of agility and scalability in chemical manufacturing.
- Support improvements in data analytics.
- Consider the potential role of Government procurement in driving demand for Australian medical products.

4. Recycling and Clean Energy

The University of Melbourne recommends that the Australian Government:

- Ensure that the Strategy:
    - Supports the development of new technologies in plastics recycling, carbon capture and storage, and the synthesis of useful chemicals from non-fossil fuel feed stocks.
    - Supports the elimination of contaminants from recycled waste.
    - Addresses the weaknesses in Australia's waste collection infrastructure.
    - Supports transparency around the cost of using virgin materials as opposed recycled materials.
    - Supports modular and mobile manufacturing innovations.
    - Supports the expansion and modernisation of the electricity grid.
    - Supports the development of renewable and low emissions technologies.

Recognise the economic and environmental opportunities associated with the recycling of batteries (e.g. mobile phones) and the recycling of polyethylene.

5. Defence

The University of Melbourne recommends that the Australian Government:

- Ensure that the Strategy recognises cognitive communications as the likely next generation of tactical networks.
- Ensure that the Strategy recognises the benefits associated with Phased Array Antenna and Multi-Function Radio-Frequency Systems Technologies.
- Support research translation.
- Provide targeted support for Defence-related research infrastructure.
- Ensure that barriers to reskilling and upskilling do not inhibit industry development.

6. Space

The University of Melbourne recommends that the Australian Government:

- Make international research collaboration a key element of the strategy for Australia's space industry.
- Consider how Australia's strength in energy research can contribute to existing research programs in other countries.
- Support the provision of micro-credentials developed in partnership with industry.

1. Resources Technology and Critical Minerals Processing

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

The University of Melbourne argues that the Resources Technology and Critical Minerals Processing priority should include a focus on the following areas:

- Hydrometallurgy and pyrometallurgy as innovative production processes for minerals.
- Processing of lithium and rare earth metals.
- Innovation in process technologies seeking step changes in yields, economics and environmental performance, and automation.
- Initiatives to add more value to raw materials.

Hydro and pyrometallurgy will be important in terms of minimising the environmental impact of the resource industries, including by extracting more from waste heaps and abandoned sites. This will be particularly true for processing mined rare earth resources. The aim is to supply the world with high grade mineral products, including rare earth metals and uranium in addition to iron ore, noting that rare earths are critical to future global supply and value chains for batteries and other electronic devices.

There is an opportunity for Australia to lift output of lithium and rare earth metals to meet global demand. For example, the Future Battery Industries CRC, of which the University of Melbourne is a member, is researching battery minerals. i.e. lithium, nickel, cobalt, graphite seeking improved process efficiency and opportunities to value-add, recycle, reuse and repurpose at end of (first) life.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Education and Training

Ensuring that Australia's education system builds and maintains an appropriately skilled workforce represents a major challenge to realising the potential of our resources and minerals sector. The University of Melbourne is a key provider of skills to the sector, for example training the next generation of metallurgists. Likewise, we will be active in the reskilling and upskilling of the current Australian workforce.

A post-secondary education system that is flexible and encourages institutional diversity will help to ensure that we meet the needs of Australia's labour market. The introduction of greater flexibility in the use of Commonwealth Grant Scheme funding is a positive change that will better position universities to respond to the needs of students and industry. Allowing a bigger role for micro-credentials and other short programs will likewise make the tertiary education sector more agile and able to respond to emerging skills needs. Micro-credentials are an efficient way to upskill and reskill, with a view to the long-term adaptability of the workforce.

Risks in translating high technology products and services

The risks associated with translating high technology products and services to practice, including the risks of commercialisation per se, is a significant barrier to investment. The University of Melbourne is increasing its emphasis on all aspects of knowledge translation, including increased entrepreneurship training for research staff, and increased support for industry engagement activities. For example, we have sought to increase our ties to the venture community through initiatives such as Melbourne Connect, Translating Research at Melbourne (TR@M), and the

Melbourne Accelerator Program. In addition, we have developed an Innovation Strategy that focusses on the Precincts of Fishermans Bend and Parkville.

Increased greenhouse gas emissions

Increased industrial intensity will typically increase our net and relative greenhouse gas emissions. New technologies in resources and minerals will need to be assessed for their carbon impact before they are adopted. The University of Melbourne is active in all aspects of technological innovation, including assessment of the potential environmental impacts.

Q4: What do you think are the measures of success for Australian manufacturing in this priority area?

Given the key challenges identified above, the University of Melbourne proposes the following measures of success:

- Increase in enrolment and completion of reskilling and upskilling courses and programs (e.g. Micro-certification courses).
- Increase in joint patent applications between industry and research institutions.
- Aggregated Value-add achieved for each base ore, over each year and three-year period. (This will involve tracing Australian purified elements into their various applications globally.)

Recommendations

The University of Melbourne recommends that the Australian Government:

- Ensure that the Modern Manufacturing Strategy include a focus on:
  - Hydrometallurgy and pyrometallurgy as innovative production processes for minerals.
  - Processing of lithium and rare earth metals.
  - Innovation in process technologies
  - Initiatives to add more value to raw materials
- Commit to a flexible education and training system that enables upskilling and reskilling opportunities to add to the agility of the sector workforce.
- Address the barriers to research translation.

2. Food and Beverage

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

Australia's food and beverage Industry should strive to be the high-end delicatessen rather than the discount supermarket. This means ensuring that Australia is a source of clean, natural and personalised products, so ensuring that our products are not re-packaged, diluted or otherwise tampered with, is very important.

Entire supply chain

Australia's food and beverage strategy should attend to all parts of the food and beverage supply chain, and should cover a broad range and scales of business-to-business and business-to-consumer industries. It is important that the strategy be sensitive to the key differences between sub-sectors:

- Some sectors, like fresh horticultural products, are characterized by large numbers of SMEs supplying a complex supply chain. Here, focus on the *entire supply chain* and the adoption of advanced technologies for tracking, traceability and inventory management will deliver significant benefits relating to product supply, quality, price and waste reduction, regardless of the production system or processing technology.
- In sectors such as broadacre grains, the weakest point in the resilience and sustainability of the whole industry may relate to the production stage and the threats posed by drought and climate change. Here the focus may need to be on innovative cropping systems, varietal development or alternative crops.
- In food sectors like meat, processing and packaging innovation may bring the best returns, associated with quality improvement and shelf-life extension.
- The profitability of other food sectors, like bottled water and soft drinks, might benefit much more from the introduction of robotics and machine learning in the factory, rather than at any other point in the supply chain.
- Parts of some sectors, like dairy and meat, may be under such serious sustainability threats that a more strategic approach, like the development of "alternative protein" industries, may be required. Regardless of whether this relates to pulse crops, seaweed, insects or algae etc., creation of a new industry sector like this will require understanding and innovation across the whole supply chain.

Research collaboration

Promoting and supporting the awareness, development and uptake of collaborative mechanisms for university research innovations for:

- Manufacturing innovations
- Food technology
- Business and supply chain management systems for critical unit operations
- Food manufacturing waste management innovations

Education and Training

There is a need for measures to support the food and beverage industry to attract and retain a high-skilled workforce in technical and managerial roles. This should include a recognition of the strong regional dimension in food manufacturing and the community connection in providing amenity, infrastructure and schools, health, housing etc. It should also include incentives for businesses to collaborate with education and training providers. Micro-credentials will be part of the long term solution.

Other areas

Other areas of focus may include:

- expanding Australia's dairy industry to compete with New Zealand,
- plant-based proteins into new markets.
- Universities working more closely with the industry to support manufacture of time sensitive products and to support transport and logistics through long-term planning initiatives.
- increasing support for food security, provenance, packaging and tamper proofing, which are big technological issues for the sector, and 'roadblocks' for SMEs.

Q2: What are the opportunities for scaling Australian manufacturing in this priority area?

The University of Melbourne endorses the recent analysis of Food Innovation Australia Limited (FIAL) in its *Capturing the Prize; the A$200 billion opportunity in 2030 for the Australian food and agribusiness sector* report. This is a valuable overview of the opportunities for growth in Australia's food sector.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Collaborative R&D

One of the biggest challenges is ensuring economic competitiveness on a global scale through active R&D partnerships. Modern Manufacturing Strategy funding should be available for food businesses to work with Universities, CSIRO and other local R&D institutions, each of which can play an important role in development of new technologies to provide competitive advantage through product innovation and / or improved productivity. However, it is also important for funding to be available for consultancy services associated with the identification, demonstration, trialling and evaluation of existing technologies, often developed overseas and expensive to access for local evaluation.

Targeted funding programs

Another great challenge is restoration of industry confidence that relates to the current underlying economic conditions identified in the Strategy. If these can be addressed successfully, then the availability of new funding, FIAL programs and associated schemes will greatly assist in rebuilding an innovation culture.

Such funding schemes need to be flexible and broad in scope, with the ability to respond to challenges and opportunities at different points in the supply chain, as well as whole supply chains. They should be able to co-fund investment in capital, in research and consultancy services, and in education and training. Eligibility criteria should extend to larger businesses as well as SMEs, recognising that larger companies can be drivers of innovation that can impact widely in the industry.

Climate change

Climate change poses significant challenges to our agricultural productivity. There may be a need to encourage relocation of agricultural production in some cases. Inevitably, we will also need to

change agriculture practices both in response to climate change and to mitigate the sector's environmental impact.

Supply chain innovation

Supply chain innovation is often limited by lack of support and participation by all players, due to the perception that benefits may not be shared. Priority should be given to innovative systems and technologies that have the potential to deliver value throughout the supply chain, including primary producers and distributors as well as processing companies and retailers.

Q4: What do you think are the measures of success for Australian manufacturing in this priority area?

Key measures of success for food and beverage manufacturing may include:

- Growth in food exports, particularly to Asian markets
- Reduction in food imports (Australia imported $14 billion in food in 2017)
- Growth in sector employment at manufacturing and production levels
- Growth in regional employment and business investment
- Growth in the overall value and profitability of Australian food manufacturing
- Strong local investment in the industry
- Enhanced reputation for sustainable growth and high-quality food products
- Reduction in food and beverage manufacturing waste

Q5: Do you have anything else you'd like to share with us in relation to the national priority areas or the manufacturing strategy?

In the context of the Food and Beverage sector, the University is leading a project named "*NorVicFoods*" which is designed to enhance the strength and productivity of the agrifood value chain in the Goulburn Valley, through initiatives in student internships, knowledge exchange with industry, and collaborative R&D.

Q6: Are there any action plans, strategies or related documents which should be considered in the development of the road maps?

The University of Melbourne is aware of many valuable reports into the Food and Beverage sector, and that we are certain the Government is aware of. We have not listed them here.

Recommendations

The University of Melbourne recommends that the Australian Government:

- Ensure that the Modern Manufacturing Strategy addresses all parts of the food and beverage supply chain, and that it is sensitive to the differences between sub-sectors.
- Promotes research collaboration between universities and food and beverage businesses.
- Commit to measures to support the food and beverage industry to attract and retain a high-skilled workforce in technical and managerial roles.
- Ensure that the Modern Manufacturing Strategy recognise the challenges that climate change poses for Australia's food and beverage industry.

- Support supply chain innovation.

3. Medical products

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

Biopharma

There is an opportunity to further expand Australia's Medtech and Pharma sector to deliver significant economic benefits to the community. According to *MTPConnect*, the Australian Medtech and Pharma sector contains ~50 pharmaceutical companies and 400 biotech companies and employs more than 48,000 people. Within this sector, the manufacture of pharmaceutical products employs ~16,000 people, with a market size of $12 billion. There has been a 28 per cent increase per year in the ASX market capitalisation of listed Medtech and Pharma companies from 2016, a rate that is more than three times the growth observed in the overall S&P/ASX over the same period. Australia's reputation for clinical trials can be leveraged to increase demand for Australian pharma production when new therapies are trialled here.

Expanding capability in this area will support sovereign control of essential public and private assets. Efficient pharma production and appropriately skilled local workforce are important to ensure Australia's resilience in face of global challenges and supply chain issues, as the COVID-19 pandemic has shown. For example, medical devices such as ventilators are challenging in that they have hundreds of parts. Where there is a high dependency on offshore suppliers, Australia may be unable to access critical medical devices when the supply chain is compromised.

We should also note that accelerated commercialisation in one sector will have spill-over benefits in others. Efficient and cost-effective local manufacturing will allow faster and more streamlined commercialisation of new technologies and solutions developed in Australia's strong biomedical sector e.g. in veterinary, wildlife or biosecurity applications.

Sovereign capability

There is a case for building Australia's capability concerning the supply of key active pharmaceutical ingredients (APIs). This will help mitigate the supply chain risks that come with critical dependence on the import of finished drugs and key APIs, including inconsistent and potentially dangerous quality issues and uncertainty around counterfeit products.

The restriction of movement and reduction in air global air capacity following the COVID-19 outbreak significantly disrupted access to APIs, particularly from China and India. While most large corporations will have inventory reserves to weather short-term disruption, the current pandemic has revealed vulnerabilities in the global pharmaceutical supply and logistics chain. Australia is a major producer of morphine and other poppy seed-based drugs, and can ensure that these products are grown in a sustainable and crime-free environment.

Relatedly, designers should be encouraged to develop medical devices with minimal number of components or parts and with all components or parts ideally sourced on-shore or with minimal dependence on off-shore supply chain.

Facilities upgrades

The National Manufacturing Priorities should include development of facilities for high-tech manufacturing that meet the medical devices standards such as ISO13485 and GMP requirements for a diverse range of processes and product types. This includes products involving cells (stem cells, primary cells, etc.) and biomaterials (hydrogels, polymers, metals, ceramics), and processes ranging from large scale cell culture to aseptic materials unit operations (extrusion, moulding, 3D printing,

etc.), which require specific cleanroom and processing conditions. Current facilities are limited in capacity and scope, making the manufacture of new products in Australia challenging. The University is a partner in the Aikenhead Centre for Medical Discovery development in Melbourne which will promote researcher-industry collaboration in med tech. Plans include development of clean room facilities for rapid prototyping of medical grade products.

Building capability through education and training

Education and training needs to be a point of focus in Australia's strategy for medical products. Significant opportunities arose for the development of medical devices during the COVID-19 pandemic. University of Melbourne innovators engaged with manufacturers who had no previous experience in the medtech sector but had the capability and capacity to manufacture components for new and innovative medical devices. These manufacturers saw an opportunity to pivot into the medtech sector. However, they had no experience in addressing the requirements of the Therapeutic Goods Administration. Developing educational programs that assist new entrants to the medtech sector to address quality management and regulatory requirements of in-country regulatory affairs agencies should be a priority. Micro-credentials will be part of the solution.

Continuous flow chemical synthesis

Traditional manufacture of APIs in the pharmaceutical industry is conducted using batch processing. This is due to the complexity of drug molecules, which require multi-step synthetic sequences, and lower production volumes compared to petrochemical and bulk chemical industries. Continuous flow synthesis is a key enabling technology that offers significant economic, quality, safety and technical advantages over the traditional batch methodologies

Additive manufacturing

Recent advances in computer-aided engineering and additive manufacturing (AM) are transforming the treatment of bone and joint diseases through the development of personalised implants and surgeries. Manufactured quickly and at low cost, personalised implants provide better outcomes for joint replacement patients. The demand for joint replacement and repair is already high, representing almost one in 10 hospital elective admissions in Australia. The ageing populations and and economic growth in Asia are driving further increases in demand. Orthopaedic and maxillofacial implants have high market share in the medtech industry, both globally and locally. In Australia, start-ups and SMEs generally lack the resources for their Research and Development (R&D) and have few pathways to assist them with understanding the regulatory environment critical to their success.

Support for research translation

There is an opportunity to leverage Australia's world-leading position in R&D to drive performance in medical product manufacturing. Australia is a world-leader in biomedical research, leading to discoveries that could underpin design and development of numerous potential products. However, Australia lacks the technology and manufacturing infrastructure to support translation of many discoveries into devices and products, and so the translation stalls or manufacturing must be done overseas, even for first-in-human studies.

Q2: What are the opportunities for scaling Australian manufacturing in this priority area?

Australia is at the forefront of development of medical technologies. This is demonstrated by the success of several world-first surgeries using personalised technologies to replace the heel bone, the jaw joint, the ribcage/sternum and simulation-based planning tools for optimising the positioning of total hip replacement. Personalised solutions will raise both industry standards and demand, achieving better patient-implant fit and patient satisfaction, especially in complex trauma and revision surgery.

There are further opportunities in better identifying gaps in local and global supply chains and in better defining unmet clinical needs. While ideas and design were in ready supply, the barriers to getting the product out into the market requires investment (e.g. purchasing new equipment) and significant lead time for a manufacturer to retool.

Australia is home to world-class facilities such as the Melbourne Centre for Nanofabrication. However, Australia lacks a semiconductor foundry and human-grade facilities for development and manufacturing of implantable medical devices, especially those that can scale to large scale manufacturing. Cochlear Ltd is an exception in this regard.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Insufficient investment

A key barrier to realising the opportunities is under-investment in the medical device manufacturing facilities. For medical devices including living cells and sensitive biomaterials, closed and automated processes are crucial to enable economic manufacturing at scale, but require investment in equipment that is often beyond the reach of early stage projects and small companies. One possible solution is to create a medical device manufacturing hub that can be used to share facilities for rapid prototyping, closed and automated processing, first-in-human manufacturing and initial scale-up to full-scale manufacturing. This could be modelled on the Melbourne Centre for Nanofabrication but have a focus upon meeting medical device manufacturing standards across the range of low- to high-tech and incorporating different types of materials and process capabilities.

Barriers to growth in personalised implants

The University of Melbourne identifies three key inhibitors to growth in personalised implants and surgeries: issues with the regulatory framework, barriers to the widespread use of medical devices, and constraints on manufacturing.

Regulatory framework

There is no well-defined regulatory framework for personalised implants and surgeries. Orthopaedic and maxillofacial implants are classified by the Australian Therapeutic Goods Administration (TGA) as high risk (Class III) devices. Implants can fail due to poor design, manufacturing or material failure. Current standards for testing off-the-shelf implants are not directly transferrable for implants that are customised to individual patients. Instead, any new regulatory, design or manufacturing framework has to be based on information from patient-specific biomechanical testing, which incorporates the patient's own anatomy, physiological loadings and tissue properties. Only then, optimal implant performance and longevity can be tailored to individual patients, as well as rapidly screening out devices with unacceptable safety risks to the patient.

Lack of a framework for the use of personalised implants

There is no well-defined framework or methodology to support the use of – and to increase the rate of success for – personalised implants. The fabrication of an implant is only the first step. Successful implantation and treatment require a comprehensive approach including optimising individual patient pre-operative planning and surgical instruments.

Barriers to manufacturing

Although personalised implant is a high-value growth area for Australian SMEs, there are significant barriers to manufacture at scale. The additive manufacturing industry for personalised implants is fragmented with several Australian SMEs emerging in the last 5-10 years. Due to the slow take up of personalised technologies (e.g. pre-clinical testing, virtual surgery and virtual clinical trials), this nascent industry is unable to manufacture at scale and be internationally competitive. Yet, any

growth in local industry will increase the demand for a highly skilled, interdisciplinary workforce to work across the AM and healthcare environment.

The University has proposed solutions to these challenges and include for example the ARC Training Centre for Medical Implant Technologies:

- create and develop knowledge and technology required for rigorous development and evaluation of pre-clinical test methods, personalised medical implants and decision support tools.
- train a new generation of engineers with a multidisciplinary R&D skillset, including knowledge of international standards, ethics, regulatory requirements and entrepreneurship for the personalised implant industry.
- coordinate and maximise the industry-university-hospital collaboration to create a supportive environment for translation and implementation, creating clearer pathways to commercialisation.

Biopharma production

The focus needs to shift from priorities of developing new drugs to developing a resilient biopharma sector that can produce these drugs at scale. This will require increasing skill sets in bioprocessing and in artificial intelligence and big data.

Lack of agility and scalability in chemical manufacturing

Australia's current approach to chemical manufacturing lacks agility and full scalability. The broad application of Flow chemical manufacturing will assist in meeting this challenge. The pharmaceutical industry is a heavily regulated industry whereby detailed control strategies are essential to ensure that products produced in the process consistently meet critical quality attributes. Although there is positive support from regulators to shift operations to continuous processes, the guidance surrounding these processes are less comprehensive than for batch production. In addition, the costly initial outlay for the installation of appropriate equipment, and training of employees may also pose as a barrier for some businesses to shift existing processes.

Data analytics

A limited capacity relating to data analytics represents a key challenge to Australia's medical manufacturing sector. Improvement in this area will require a greater focus on innovation with government funding targeted toward University-industry-hospital engagement, co-design, and toward integration of technological innovations in complex manufacturing chains.

Government procurement

Governments need to clarify their respective roles in stimulating these manufacturing sectors, for example, its role in driving demand through procurement. Taken together, all levels of government represent the biggest consumer in the country. Governments can use public purchasing to influence demand.

Q4: What do you think are the measures of success for Australian manufacturing in this priority area?

Key measures of success for medical products manufacturing may include:

- Number of biomedical research outputs translated into products manufactured in Australia, or services provided by Australian institutions.
- Number of biomedical research outputs translated to the point of a clinical trial.

- Measures of manufacturing efficiency (eg. higher throughput, decreased waste with more stringent specifications).
- Number of people employed in jobs requiring higher education in the sciences or engineering.
- Number of people employed in jobs requiring high technical expertise.
- Number of new devices being manufactured in Australia.
- Number of new devices submitted for regulatory approval.
- Import replacement in component value chains.

Q6: Are there any action plans, strategies or related documents which should be considered in the development of the road maps

The University of Melbourne has been constructing clean room facilities jointly with the Bionics Institute. This could be used as a template for a nation-wide initiative. Also, we are in discussions with two other training centres (Sydney and QUT) about a possible CRC or ARC CoE bid. We are also discussing with UTS to develop a National Testing Centre (ISO) to support local and Asia Pacific medical device industry.

Recommendations

The University of Melbourne recommends that the Australian Government:

- Commit to measures to grow Australia's Medtech and Pharma sector.
- Ensure that the Strategy recognises the importance of enhancing sovereign capability, particularly in active pharmaceutical ingredients (APIs).
- Commit to upgrades that address the limitations in Australia's current stock of medical product facilities.
- Support capacity building through targeted support for education and training programs.
- Ensure that the Strategy recognises the benefits of Continuous flow chemical synthesis.
- Ensure that the Strategy recognises the benefits of Additive manufacturing.
- Provide targeted support for research translation.
- Address the inhibitors to growth in personalised implants and surgeries.
- Address the lack of agility and scalability in chemical manufacturing.
- Support improvements in data analytics.
- Consider the potential role of Government procurement in driving demand for Australian medical products.

4. Recycling and Clean Energy

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

The University of Melbourne argues that the framework for building capability around recycling and clean energy should include:

- Development of novel technologies for:
  - plastics recycling,
  - metals recycling,
  - carbon capture and storage,
  - synthesis of useful chemicals from non-fossil fuel feed stocks.
- Eliminating emerging contaminants (e.g. PFAS, microplastics) from recycled waste/new product streams.
- Addressing the weakness in the nation's waste collection infrastructure, through adoption of global best practice.
- Transparent economic and financial reporting on the full costs of using virgin materials as opposed to recycled materials in manufacturing, which includes water, carbon and energy footprints.
- Implementation of modular and mobile manufacturing innovations.
- Expanding and modernising electricity grids.
- Development of renewable and low emissions technologies to meet internationally benchmarked emissions targets.

Q2: What are the opportunities for scaling Australian manufacturing in this priority area?

Key areas of opportunity in recycling and clean energy include:

- Recycling of batteries (e.g. mobile phones)
- Integration of the elements recovered from batteries into our broader minerals processing sector.
- Recycling of polyethylene, as the only plastic produced at scale in Australia.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Collaborative R&D

One of the biggest challenges is ensuring economic competitiveness on a global scale through active R&D partnerships. Modern Manufacturing Strategy funding should be available for Recycling businesses to work with Universities, CSIRO and other local R&D institutions, each of which can play an important role in development of new technologies to provide competitive advantage through product innovation and / or improved productivity. However, it is also important for funding to be available for consultancy services associated with the identification, demonstration, trialling and evaluation of existing technologies, often developed overseas and expensive to access for local evaluation.

Q4: What do you think are the measures of success for Australian manufacturing in this priority area?

Key measures of success for recycling and clean energy may include:

- Proportion of foreign-supplied key chemicals and fuels have been replaced by Australian-sourced, recycled products.
- Proportion of Australian-derived waste products that are exported for recycling overseas.
- Jobs created in Australian businesses built around recycling of waste.

Recommendations

The University of Melbourne recommends that the Australian Government:

- Ensure that the Strategy:
  - Supports the development of new technologies in plastics recycling, carbon capture and storage, and the synthesis of useful chemicals from non-fossil fuel feed stocks.
  - Supports The elimination of contaminants from recycled waste
  - Addresses the weaknesses in Australia's waste collection infrastructure.
  - Supports transparency around the cost of using virgin materials as opposed recycled materials.
  - Supports modular and mobile manufacturing innovations.
  - Supports the expansion and modernisation of the electricity grid.
  - Supports the development of renewable and low emissions technologies.
- Recognise the economic and environmental opportunities associated with the recycling of batteries (e.g. mobile phones) and the recycling of polyethylene.

5. Defence

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

Cognitive Communications

Cognitive Communications are likely to be the next generation of tactical networks. The emergence of advanced communications for 5G and 6G networking of devices will require advanced electronics and radio-frequency engineering expertise. This means supporting SMEs to design and manufacture specialised RF devices including miniature microwave integrated systems, antennas, software radio systems integrated into devices. It will also require the development of large research labs based in Universities but with considerable industry colocation. The NCRIS-funded Australian National Fabrication Facility (ANFF) could be further developed to provided clean rooms for the manufacture of advanced circuitry.

There will also need to be an increase in the ability to manufacture meta or functional materials with special radio-frequency properties. Many of these advanced devices require functional materials to operate efficiently and effectively.

Phased Array Antenna and Multi-Function Radio-Frequency Systems Technologies

There are considerable opportunities for Australia's defence industry in the development of in Phased Array Antenna and Multi-Function Radio-Frequency Systems Technologies. Australia could play a leading role in the supply chain of advanced device manufacture around the world, as well as developing sovereign capability to support specialist defence devices that may not be obtainable from the US or Europe due to the sensitive nature of these devices. This includes the development of advanced phased array technology. Currently only one company in Australia builds defence phased arrays. It is necessary to build a national base around this company of small companies and universities able to support the development of next generation antenna technology including: Power amplifiers, functional materials for antenna faces, radio-frequency engineers, large scale simulation and system modelling for testing, test facilities including anechoic chambers.

Australia is well-positioned to capitalise on opportunities in these areas. Both cognitive communication and phased array technologies demand significant capability in science and engineering, are complex and often personalised/customised, and demand a highly skilled workforce. Hence, there is an opportunity to leverage Australia's strength in these areas.

It is also important to note that Australia will rarely receive the latest technology from other nations There is an opportunity for Australia to be a leading developer of advanced communication and phased array technology. The next generation of phased array technology, such as used in ships and planes, will require much more advanced materials and Radio Frequency systems design that is currently not developed sufficiently in Australia.

Q2: What are the opportunities for scaling Australian manufacturing in this priority area?

Research collaboration

Consideration should be given to support the development of large laboratories in universities to drive collaboration between researchers and industry, particularly involving high-tech SMEs. There is the opportunity for Australia to stop being the smart adopter of technology and become part of the global supply chain. This could be undertaken by scaling up a few University electrical and electronic laboratories and providing industry funding schemes for SMEs to make use of the labs. This would also allow students to transfer more easily to the companies and to have the students more "job

ready" as they will have been dealing with the companies. This requires colocation of companies within the university as well as laboratories fitted with the latest electronic equipment and test facilities.

In parallel, specialist manufacturing facilities could be developed that allowed Australia to input into the supply chain of products by manufacturing either prototypes or direct manufacture for sale.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Research infrastructure

Defence already has a strong innovation fund and a way of integrating universities and industry. However, there is a need to address the scale of high-tech infrastructure required for a vibrant microelectronics (communications and advanced RF systems) industry and university sector. Most of the university laboratories are small. An injection of funding, linked to industry participation, would allow industry and universities to share electronics design and fabrication capability.

Reskilling and upskilling

Artificial barriers in the skills system that prevent individuals from upskilling will undermine the defence industry's development. The University of Melbourne has been active in developing micro-certification programs in partnership with industry. Investment in training programs such as these would encourage industry participation in the development of skills relating to new technologies.

Q4: What do you think are the measures of success for Australian manufacturing in this priority area?

The University of Melbourne suggests that measures of success should focus on industry-university collaboration, e.g. the number of SMEs partnering with universities or co-located in university labs, and the number of industry-embedded PhD students. A collaborative partnership model would allow for one or two laboratories to be utilised by a number of universities and allow for connections to other locations i.e. through a 'virtual institute' approach. This is similar to how the National Information and Communications Technology Research Centre of Excellence was modelled in the 2000s.

Recommendations

The University of Melbourne recommends that the Australian Government:

- Ensure that the Strategy recognises cognitive communications as the likely next generation of tactical networks.
- Ensure that the Strategy recognises the benefits associated with Phased Array Antenna and Multi-Function Radio-Frequency Systems Technologies.
- Support research translation.
- Provide targeted support for Defence-related research infrastructure.
- Ensure that barriers to reskilling and upskilling do not inhibit industry development.

6. Space

Q1a: Which areas of pre-production, production and post-production do you think should be included in this National Manufacturing Priority?

Q1b: Why are these areas important to this priority?

International collaboration

There are considerable opportunities for Australian researchers through deepening our engagement with international partners. Part of this should involve identifying where our research strengths complement existing research programs elsewhere. For example, 'DLR' (German Aerospace Centre) has a particular focus on energy-related solutions to the challenges of space exploration. The research expertise Australia's enjoys in this area represents a key opportunity. There is the possibility, for example, to contribute to this research program through the development battery technologies for powering spacecraft and bases.

University of Melbourne initiatives

The University of Melbourne is contributing to a range of initiatives in space research. Two such initiatives are 'SpIRIT' (Space Industry – Responsive – Intelligent – Thermal Nanosatellite) and 'Melbourne Space Program'.

SpIRIT

SpIRIT will become the first Australian-made spacecraft to host a foreign space agency payload when it is launched in 2022. This will showcase the value of Australia's nanosatellite R&D and advanced manufacturing, breaking new ground in high-performance autonomous operations, communications, propulsion and thermal management.

Melbourne Space Program

Initially formed by a group of students from the Melbourne School of Engineering, Melbourne Space Program is a not-for-profit organisation that aims to launch the next generation of technology pioneers. The Program's successes include the launching of the ACRUX-1 CubeSat satellite in 2019. This project was funded by Student Services and Amenities Fee (SSAF) Grant Program from the University of Melbourne.

Q3: What are the challenges to seizing these opportunities, and what are your proposed solutions?

Education and Training

Investment in training programs, with an injection of funding linked to industry participation, would help realise the opportunities offered by the Space industry. The University of Melbourne is drawing from its expertise in science, engineering and law to develop micro-credentials in this field. These micro-credentials are to be co-designed with industry, and will offer online assessable content.

Recommendations

The University of Melbourne recommends that the Australian Government:

- Make international research collaboration a key element of the strategy for Australia's space industry.
- Consider how Australia's strength in energy research can contribute to existing research programs in other countries.
- Support the provision of micro-credentials developed in partnership with industry.