ADVANCE QUEENSLAND

Queensland Advanced Manufacturing 10-Year Roadmap and Action Plan - powering the Queensland economy

December 2016

Queensland Government

Image acknowledgements:
B&R Enclosures, Bundaberg Brewed Drinks, Centre for Advanced Materials Processing and Manufacturing (University of Queensland), EM Solutions, Ferra Engineering, Griffith University, Hackerspace Brisbane, Heat Treatment Australia, L-3 Micreo, National Centre for Engineering in Agriculture (University of Southern Queensland), Patheon, Surface Pro and TAE.

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Foreword

The Queensland Government is committed to growing manufacturing in this state as a critical driver of innovation and productivity in the economy. An important leading edge to manufacturing is the advanced manufacturing sector which comprises the technological advancements of manufacturing in terms of products, processes and innovative business models. Part of the Queensland Government's Advance Queensland agenda, this Advanced Manufacturing 10-Year Roadmap and Action Plan (the roadmap) is designed to set a path for the growth of advanced manufacturing, fostering the continued transition of existing manufacturers into world-class advanced manufacturers and creating high paid, sustainable jobs for Queenslanders.

This roadmap has been developed through consultation with industry and other stakeholders with over 100 respondents. It has also benefited from the expert input of the Industry and Manufacturing Advisory Group (IMAG) which I established in November 2015.

The Queensland Government's vision for the advanced manufacturing sector is that by capitalising on its competitive strengths across the manufacturing sector, particularly in the areas of: aerospace; automotive and transport; biomedical and life sciences; defence; food and beverage processing; industrial biotechnology and bioproducts; mining equipment, technology and services; precision agriculture; and renewable energy, Queensland will be recognised as a national and international leader for its high-value advanced manufacturing technologies, products, systems and services that are innovative, sustainable and embedded in local and global supply chains.

This vision will assist those manufacturers wanting to become advanced manufacturers and support existing advanced manufacturers to expand their businesses in this state.

We intend to continue partnering with industry in the roll-out of this roadmap. The programs we are introducing will drive innovation, improve workforce and business skills and build on our competitive advantages to help raise our profile as an attractive investment destination.

Advance Queensland provides an umbrella for a number of roadmaps which in themselves contain significant segments of the manufacturing industry. This roadmap, through a number of its initiatives, will also support the other roadmaps.

Given the pace of change that has affected the industry over the past 10 years, it is the government's intention that this 10-year roadmap will be regularly reviewed and revised to respond to changes in technology and the economy that will impact on the industry. The IMAG will have a central role in these reviews.

The Queensland Government has also commenced a Queensland Productivity Commission Inquiry into Queensland Manufacturing to examine ways to improve the productivity and competitiveness of the manufacturing industry. This Inquiry will complement the roadmap and contribute to its continuing refinement.

Advanced manufacturing has the potential to contribute significantly to the Queensland economy. With potential for innovative sector growth, a fully pro-business government, and an abundance of competitive advantages, Queensland is the future of Australian enterprise and industry.

The Hon. Dr Anthony Lynham MP

Minister for State Development
and Minister for Natural Resources and Mines

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Our vision

Capitalising on its competitive strengths in existing and emerging sectors, Queensland will be a recognised leader, nationally and internationally, by 2026 for its advanced manufacturing technologies, products, systems and services that are innovative, sustainable, and embedded in local and global supply chains.

The Queensland Government is committed to diversifying the Queensland economy to strengthen its international competitiveness, grow the economy and generate the high-value, high-skilled jobs of the future.

Through Advance Queensland, the Queensland Government has a clear ambition to pursue the innovation-driven economic growth that leads to jobs now, and into the future. Advance Queensland programs focus on areas where Queensland possesses a genuine competitive advantage for turning ideas into products and services that deliver real outcomes for the state. This includes commercial opportunities that build businesses, strengthen industries and provide for global trade and investment opportunities.

Advance Queensland is also delivering 10-year roadmaps for industries with global growth potential. Advanced manufacturing is one of these industry sectors. No country or state can be an innovation leader without an innovative manufacturing sector, and this is fundamentally why the Queensland Government is supporting manufacturing in this state—in addition to its contributions to employment and exports.

Australian manufacturers are facing significant challenges in remaining globally competitive. They need to improve productivity, produce more from less and build competitive sustainability.

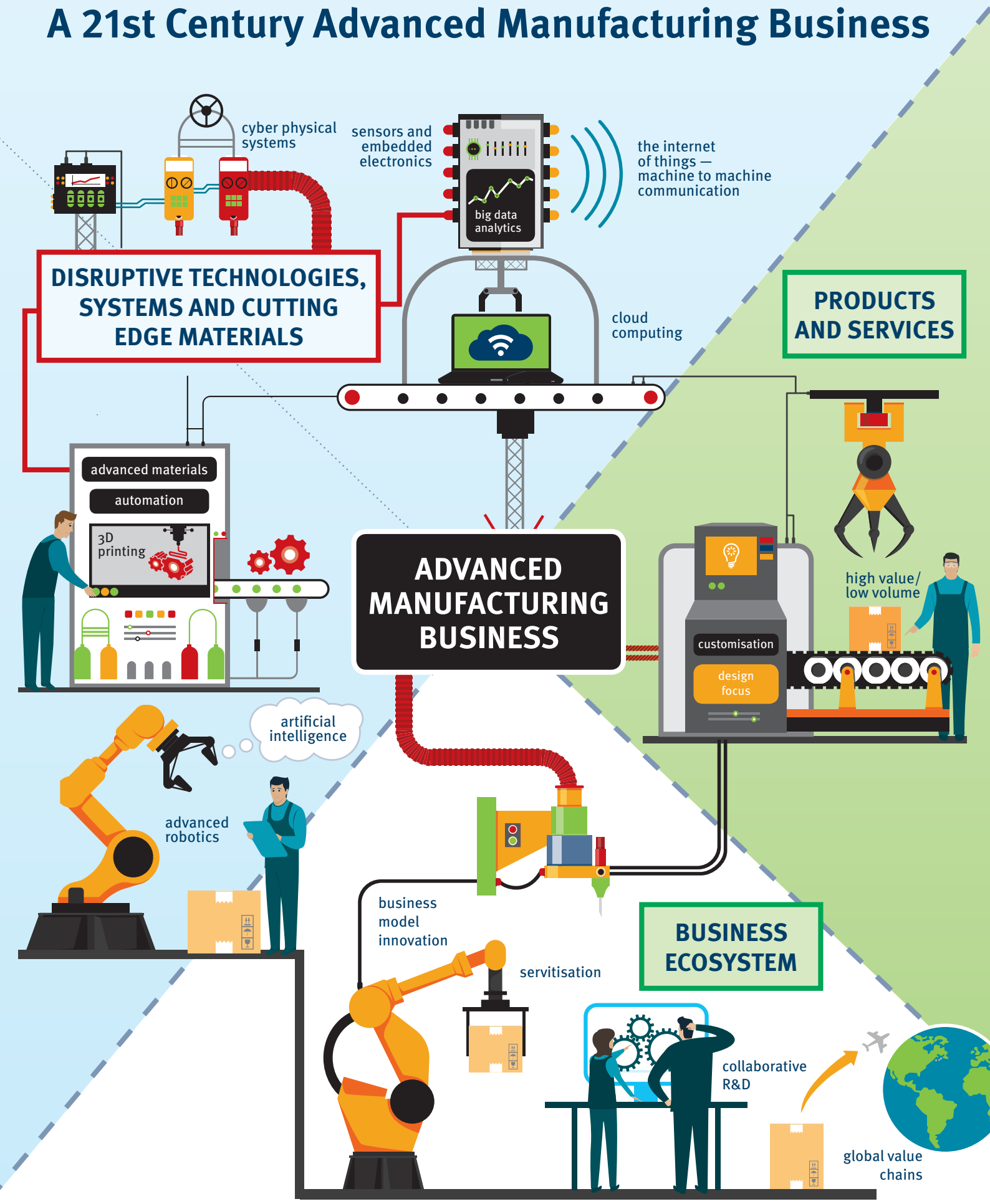
According to Deloitte Australia[1]:

Twenty-first century manufacturing competitiveness is increasingly propelled by advanced technologies and there is a convergence of the digital and physical worlds—both within and beyond the factory—to both customers and suppliers, creating a highly responsive, innovative and competitive global manufacturing landscape.

Given these global trends, the uptake of advanced manufacturing techniques by Queensland manufacturing is the key to future consolidation and growth. These innovations change the basis of competition for Australian manufacturing away from cost only—which suits the structure of the local manufacturing sector.

The Queensland Government is committed to supporting the advanced manufacturing sector which comprises innovative business models and the technological advancement of manufacturing in terms of products and processes. Advanced Manufacturing is the cutting edge of manufacturing and is vital to its continuing growth in this state as a critical driver of innovation and productivity.

A 21st Century Advanced Manufacturing Business



The manufacturing industry will be a backbone of the overall economy, but it will be a different manufacturing industry. It is not about mass manufacturing of goods, like cars or fridges or whitegoods. It is going to be of higher value and highly-specialised manufacturing. For example, this is evident in the emergence of connected devices, smart homes, smart environment, assisted technologies for the ageing society, higher value individualised medicine, drugs and devices,and bio-fabrication especially to service the ageing society.[2]

The government is keen to ensure more Queensland manufacturing businesses seize the opportunities to supply high-value goods and services into global supply chains and export markets in the following areas:

- aerospace
- automotive and transport
- biomedical and life sciences
- defence
- food and beverage processing
- industrial biotechnology and bioproducts
- mining equipment, technology and services
- precision agriculture
- renewable energy.

To assist business on this journey, the government is focused on creating a supportive business environment that encourages innovation, investment and growth.

The Queensland Government has developed the Advanced Manufacturing 10-Year Roadmap and Action Plan to realise our vision for the sector. Its aspiration for the advanced manufacturing sector is that by 2026 the sector will comprise internationally competitive businesses that build on potentially disruptive technologies that include advanced materials, advanced automation, 3D printing, artificial intelligence, sensors and embedded electronics to produce customised products. These businesses will demonstrate strong information and communication technology (ICT) expertise and capacity, operate in global value chains and focus on exporting and adopting sustainable manufacturing practices to reduce inputs, waste and costs. Central to their operations will be the Internet of Things (IoT), where a network of data gathering sensors and cloud computing enables machine-to-machine communications.[3] Their use of big data analytics will lead to cost reductions and more agile decision making and they will provide services to support customised products through a process called servitisation.

Some of the businesses might be 'micromultinationals' which are smaller, interdependent businesses that combine virtual and physical networks and operate around the world and around the clock across multiple time zones.[4]

What is advanced manufacturing?

In November 2015, Brent Balinski explained in Manufacturers' Monthly that:

While there is no universal definition of the term 'advanced manufacturing' there is a consensus that it involves an holistic approach to the way a manufacturing business operates, with a high level of technology and expertise applied throughout every step of a value chain.[5]

Advanced manufacturing incorporates market products and a range of activities from design and research and development (R&D) to production, distribution and after-sales services.[6] It includes:

- collaborative R&D and design-led thinking
- innovative business models and effective supply chain capabilities
- the effective use of disruptive technologies, systems and cutting-edge materials
- a focus on customisation and exports
- world-best practices and processes
- new ways to manufacture existing products and the manufacture of new products
- the provision of high value-added services and innovative solutions.

Advanced manufacturers use and integrate new technologies, design and innovative production systems to produce high-value products and smart services across key industry sectors which, in Queensland, include: aerospace; automotive and transport; biomedical and life sciences; defence; food and beverage processing; industrial biotechnology and bioproducts; mining equipment, technology and services; precision agriculture; and renewable energy.

Some of the key enabling technologies identified by the United States' President's Council of Advisors on Science and Technology in 2011 as supporting advances in manufacturing in the future include the following:[7]

***Advanced robotics**—next-generation robots could be mobile and autonomous in their environment, with the ability to interact with their environment and achieve outcomes without programming of all procedures.*

***Nanoelectronics**—semiconductors have been one of the key enabling technologies of the information technology revolution. The technology has driven ongoing improvements in price and performance of computers, phones and other communications equipment.*

***Materials by design**—materials that endure in extreme temperatures, lightweight composites and new electronic and functional materials have in the past enabled advances in transportation, electronics and aerospace.*

***Biomanufacturing**—researchers are developing new tools to enable them to readily engineer biological systems, with widespread applications for energy, medicine, and electronics.*

Queensland has significant research strengths in all of these areas, as described in Appendix A.

*these sectors will have a Roadmap

Queensland manufacturing - an industry snapshot

Historically, Queensland's manufacturing sector has not been characterised by the manufacture of large volumes of standardised products, often on an assembly line. Consequently, the state has been less affected by the downturn in traditional (broad based) manufacturing undertaken in the southern states. Queensland's history of smaller, more flexible manufacturing operations is suited to the emerging manufacturing paradigm of smaller production runs of customised products.

> *Manufacturing is not an 'old' industry—it is in fact the most innovation-intensive sector of the entire economy, generating better-than-average productivity growth, good jobs, and exports. Most importantly, manufacturing possesses several key structural features that make it vital to the economic success of any economy —including Australia's.*[8]

Contribution to Queensland economy

In 2014–15 manufacturing contributed around $20.3 billion to the Queensland economy.

Over the past decade, Queensland manufacturing has increased its share of national industry gross value added from 16.8% in 2004–05 to 19.7% in 2014–15 (in current prices). However while Queensland manufacturing makes a significant contribution to the state's output, it has decreased its share of output from 12% in 1989–90 to 7.1% in 2014–15 (current prices).

Employment

In the September quarter 2016, manufacturing directly employed around 167,400 people in Queensland. Over 88% of manufacturing jobs are full-time positions. In terms of total employment, the industry is the seventh largest in the state and despite some strong growth areas, employment in manufacturing is expected to remain flat over the medium term with output growth likely to be driven by productivity improvement. The sector comprises around 9,000 enterprises, the majority of which are small and medium sized enterprises (SMEs), which equates to 5.7% of total employing businesses in Queensland as at the end of the 2014–15 financial year. For the year ending September quarter 2016, Greater Brisbane accounted for 55.4% of total manufacturing employment across the state, with the 'rest of Queensland' regions accounting for the remaining 44.6%. The largest regional shares were Gold Coast (11.5%), Wide Bay (5.5%), Sunshine Coast (4.8%), Mackay (4.6%) and Fitzroy (4.5%).

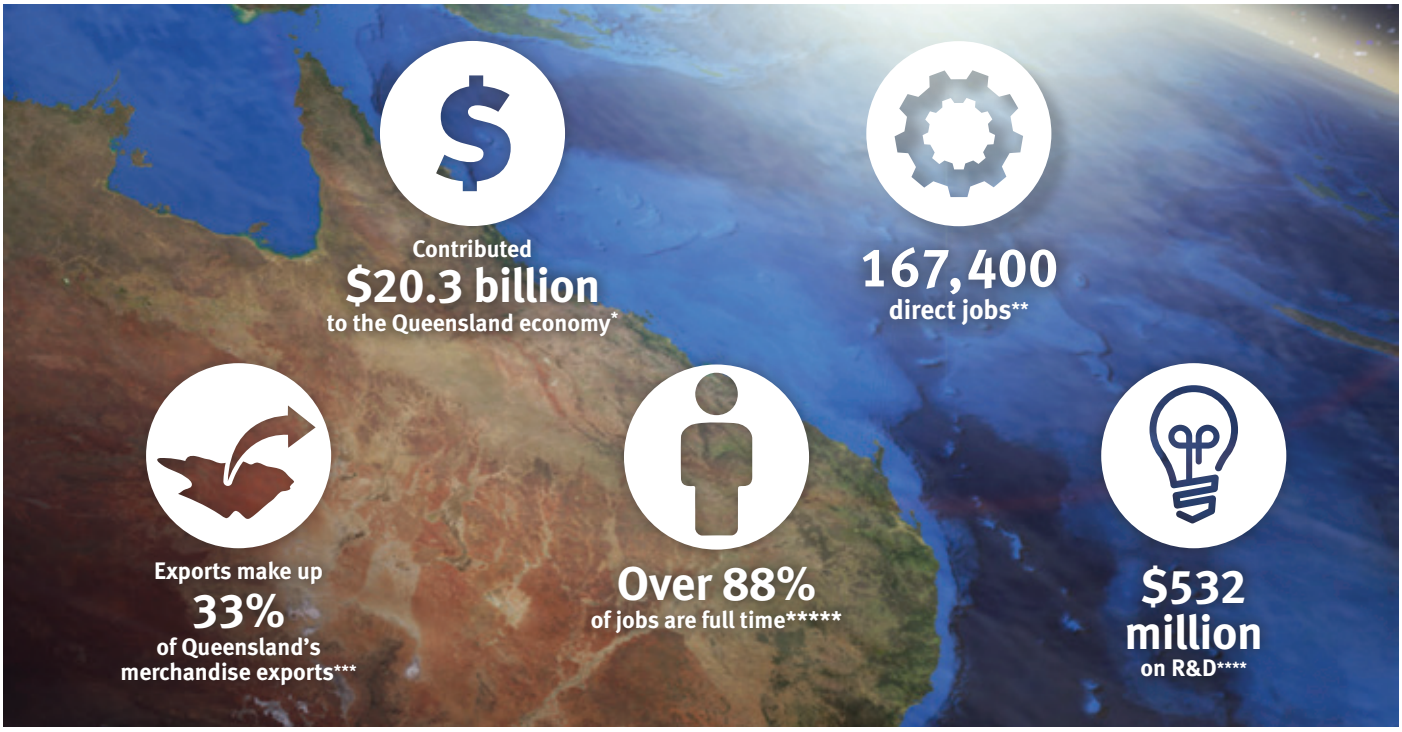
Exports

In 2015–16 manufacturing accounted for $15.7 billion in international exports, making it one of the largest export industries in Queensland representing around 33% of the total value of Queensland's merchandise exports.

Research and Development

Queensland manufacturing spent $532 million on R&D in 2013–14, accounting for 19.7% of total business R&D in Queensland.

Manufacturing in Queensland is diverse, ranging across food and beverages, metal products, non-metallic mineral products, machinery and equipment, petroleum, coal, chemical, polymer and rubber products, printing and recorded media, textiles, clothing, furniture and wood and paper.



*In 2014–15 **In the September quarter 2016 ***In 2015–16 ****in 2013–14 *****November 2015

Researchers at the National Centre for Engineering in Agriculture (NCEA) at the University of Southern Queensland's (USQ) Toowoomba campus, are developing adaptive systems that sense, control and monitor farming inputs such as water, fertiliser and chemicals by using variable rate technology, unmanned aerial vehicles (drones) and proximal sensors (ie. in soils and crops) that function in real time.

In 2014, USA based machinery manufacturing company John Deere and USQ signed a research partnership agreement wherein researchers at USQ's NCEA will work with John Deere's Advanced Engineering Group at Urbandale, Iowa, USA on technologies that will benefit Australian and overseas growers by reducing farm related growing costs.

The research aims to enhance existing technology and develop new innovations for the company's tractors and other farm equipment including the next generation of technologies released by John Deere. The relationship will also foster training opportunities for researchers and offer postgraduates research opportunities to work with a world leader in machinery manufacturing.

Industry drivers

Growing Asia- and Indo-Pacific middle class

In 2014 a joint Telstra and CSIRO report, Make for Asia, found that by 2030 the global middle class would comprise 4.9 billion of which the Asia- Pacific share would be around 3.2 billion people.[9]

These trends coupled with the shift in the global economy from West to East are forecast to generate a 'dining boom' with global demand for food increasing by up to 75% by 2050.[10]

Ageing population

The ageing population worldwide is creating strong demand for a wide range of products and services particularly in the healthcare, medical and pharmaceutical industries. The 2014 joint Telstra and CSIRO report, Make for Asia, noted that by 2050 Asia will be home to 24% of those aged over 60 and this trend will have significant implications for health care expenditure with the increasing demand for products such as dental implants and titanium hip replacements to preserve a high quality of life.[11] The ageing population is also impacting adversely on the availability of advanced manufacturing expertise as many skilled employees retire. However this cohort could also be a source of capable mentors to the younger generation.

Sustainability

In the 2013 Ernst and Young 'Cleantech Industry Performance' report that listed an 18% global market capitalisation growth over the previous 12 months, the Asia-Pacific region was identified as experiencing the greatest increase in the number of companies and employees in the cleantech market.[12] [13] This trend reflects the growing opportunities for businesses providing the technologies, products and systems for sustainable use and storage of energy, waste and water as nations strive to grow environmentally sustainable economies.

Disruptive impact of technology

The increasing pace of change arising from new and emerging technologies is having a disruptive impact on traditional jobs, businesses and industries and enabling countries that had previously competed for low-cost, low-skilled jobs to compete for high-skilled jobs and produce high-value goods.[14]

Digitisation is integral to the technological changes occurring worldwide. Its impact on the product development process leads to a merging of design, production planning, engineering, manufacturing and services into one unit resulting in more efficient production and greater economies of scale and speed to market.[15]

Increasing security pressures

In addition, the changing security landscape, highlighted in Australia's 2016 Defence White Paper, has stimulated investment in new capabilities over future decades to safeguard Australia. These capabilities include enhanced intelligence, surveillance and reconnaissance, space, electronic warfare and cyber capabilities.[16]

In the face of strong competition from developed countries with well-established and sophisticated manufacturing industries and low-cost manufacturers in emerging nations, Queensland will need to intensify its focus on developing innovative products and services in areas of competitive advantage to remain internationally competitive.

Industry 4.0 is the next phase in digitisation and it will transform manufacturing in the 21st century.[17] It is being driven by four disruptions:[18]

1. *big data (capturing more data from sensors can lead to increased yields)*
2. *advanced analytics (can be used to improve product development)*
3. *human-machine interfaces (can lead to reduced errors)*
4. *digital-to-physical transfers (e.g. advanced robotics and 3D printing that can minimise the time to market).*

Global and national initiatives

Manufacturing's significant role in driving productivity, growth, innovation and trade is internationally recognised. The sector contributes twice as much to productivity growth as its employment share and it typically accounts for the largest share of an economy's foreign trade; generating 70% of exports across major advanced and developing economies.[19]

Manufacturing's decline as a share of output across the Organisation for Economic Cooperation and Development (OECD) economies has prompted leading economies to focus on revitalising their manufacturing sectors.

The United Kingdom, Germany and the United States of America (USA) governments have significantly funded initiatives designed to nurture manufacturing innovation and accelerate commercialisation. These initiatives, that include the High Value Manufacturing Catapult, the Fraunhofer Society and Manufacturing USA respectively, capitalise on the opportunities arising from strong research and industry collaboration and long-term national government support. In Germany, the Fraunhofer Society is important for many businesses that produce speciality products that are not only sold locally but around the world for high prices.[20] Japan and Korea have also invested heavily in R&D in their manufacturing industry with the former strengthening intellectual property rights and decreasing royalty costs to increase entrepreneurship.[21]

A key feature of these international initiatives is the national support for industry and research collaboration. The Queensland Government aims to bolster research and industry collaboration in a range of sectors, including advanced manufacturing, through its Advance Queensland programs designed to create the knowledge-based jobs of the future and through the actions in this roadmap.

A notable initiative that has emerged internationally and nationally over the last 10 years is 'hacker/maker spaces' interchangeably referred to as hackerspaces, makerspaces, TechShops, and FabLabs which are community spaces offering public, shared access to high-end manufacturing equipment. These spaces function as centres for peer learning and knowledge sharing, in the form of workshops, presentations, and lectures and have been supported by various governments as a means to encourage young people into manufacturing to promote entrepreneurship and develop skills. Queensland has a number of hacker/maker spaces established and this roadmap will provide support for this concept.

The government will continue to monitor international trends to identify opportunities and learnings for Queensland.

Hackerspace Brisbane (HSBNE) is Australia's first Hackerspace, and one of the physically largest in the world. Located at Eagle Farm in Brisbane, HSBNE provides a campus with a growing wealth of tools, large and small, to allow anyone to build and create.

HSBNE has a number of separate workspaces with facilities and tooling for woodworking, metalworking, machining, welding, car repair, cosplay, sewing, craft, laser cutting, electronics, 3D printing, soldering and teaching. Furthermore, there is a large collection of donations for scavenging parts and recycling called the Boneyard. This range of facilities allows greater interdisciplinary projects and collaborations for DIY projects, prototyping, repurposing and product development.

A membership funded community organisation, HSBNE is open to anyone to tinker and invent. HSBNE encourages people to understand how the technology in their daily lives works, and the value in repurposing broken equipment. Much of the tooling, desks, storage and equipment is made from scratch by members for members, for example a 3D printer made out of 3D printed parts and parts scavenged from an old photocopier.

HSBNE is run by a group of appointed volunteer members. Visit **hsbne.org** for further information.

The Queensland Government will leverage Australian Government programs and agreements that could support advanced manufacturing in Queensland.
These include the:

- **Innovative Manufacturing Cooperative Research Centre**—established to develop and support 'manufacturing innovation' in Australia across a range of key growth sectors
- **Advanced Manufacturing Growth Centre**—established to place science at the centre of industry policy and increase business, industry and research collaboration
- **Free Trade Agreements and major reforms** to anti-dumping laws to further protect manufacturers from cheap imports
- **R&D Tax Incentive program**—providing tax relief of almost $3 billion to more than 13,000 innovative Australian companies.

The Queensland Government will also encourage businesses transitioning to advanced manufacturing to engage with CSIRO on relevant programs including the Future Manufacturing National Research Flagship which is a key foundation of CSIRO's sustainable manufacturing strategy. By focusing its research program on technologies that include: Sustainable Materials; Flexible Electronics; Advanced Engineered Components and Advanced Fibrous Materials, CSIRO seeks to assist Australian manufacturing to become more internationally competitive.[22]

James Cook University (JCU) is utilising its Townsville city campus, as well as undertaking low-cost repurposing of buildings, to create a design and build hub (hacker/maker space) for the research community, industry and the wider community to develop prototypes and turn ideas into reality. In 2017, JCU's Cairns campus is offering 'Electronic Systems and Internet of Things' as a new area of specialisation after completion of a general first year in engineering—this is the first course of its kind in Australia.

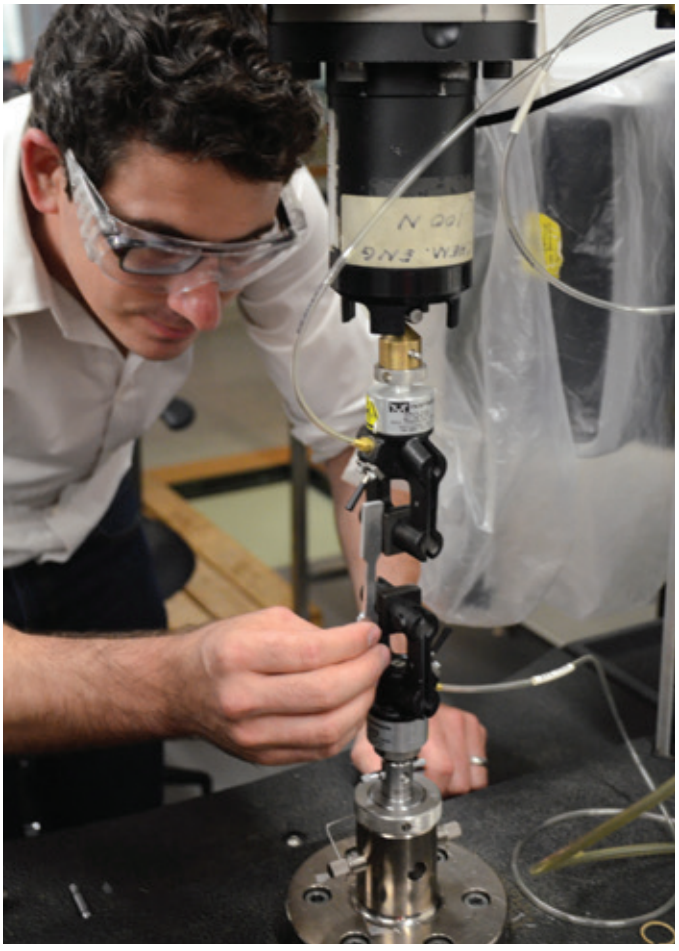
Similarly the introduction of the Australian Government's National Disability Insurance Scheme (NDIS) will provide all Australians born with or who acquire a permanent and significant disability before the age of 65 with support to live a better life.[23] There will be opportunities for Queensland's advanced manufacturing businesses to provide assistive technologies, which include any device, system or design that assists individuals carry out daily living activities. This roadmap will explore how Queensland's advanced manufacturing industry might be best positioned to address this emerging opportunity.

Actions to date

Industry and Manufacturing Advisory Group

In November 2015, the Queensland Government established the Industry and Manufacturing Advisory Group (IMAG), comprised of industry and union representatives, to provide advice on the development of the roadmap.

The actions in this roadmap will dovetail with the actions of the other 10-year roadmaps to be developed by the Queensland Government in areas of competitive advantage and potential growth.



Advance Queensland

The Queensland Government has a clear plan to drive employment and economic growth. To create a diverse, knowledge-based economy, it is vital that the state's innovation system works seamlessly from the generation of ideas to the generation of jobs. With funding of $405 million, the Advance Queensland initiative will build future generations, grow our regions, further unlock the potential of business to innovate, and further harness our existing strengths and foster emerging opportunities.

Programs of interest to advanced manufacturing include:

$6 million **Advancing Regional Innovation Program** that will support regional innovation by connecting local efforts, leveraging key regional strengths and lifting the capability of innovative local firms.

$10 million **Platform Technology Program** that will encourage the development and deployment of platform technologies (for example, unmanned aerial vehicles) in existing and emerging industries such as aerospace, agriculture, defence, disaster management and environmental monitoring.

$10 million **Ignite Ideas Fund** supporting the development of new or improved products, processes or services to secure investment, launch into global markets and grow business.

$40 million **Business Development Fund** helps to turn ideas into reality with co-investment in emerging and high-growth Queensland businesses at the forefront of commercialising innovative research or ideas.

$8 million **Knowledge Transfer Partnerships Program**, providing up to $50,000 to businesses to employ graduates on strategic innovation projects. This program supports collaboration and knowledge transfer by enabling businesses to partner with universities to select graduates for specific projects in the businesses.

Innovation Partnerships to position Queensland as a global innovation hub with grants of up to $1.5 million awarded to Queensland research organisations to collaborate on research projects with industry.

Innovate Queensland delivered by a third party provides a range of skills-based and collaborative solutions for businesses and early stage innovators seeking to benefit from innovation and technology commercialisation. These programs specifically target innovative, knowledge intensive businesses for growth in Queensland, including those in the advanced manufacturing sector.

Advanced manufacturing is also one of the **Science and Research Priorities** identified by the Queensland Chief Scientist as an important enabler to deliver productivity growth and jobs for the state.[24]

Additionally, the Queensland Government is actively delivering a suite of industry attraction and facilitation services, with the aim of encouraging the relocation and establishment of new projects, or reinvestment and expansion of existing operations in Queensland.

One of these tools, the $40 million **Advance Queensland Industry Attraction Fund**, targets growth companies in priority industry sectors including advanced manufacturing. All project proposals seeking financial assistance through the fund will need to meet a clear set of principles and criteria ensuring that any financial incentives flow through to the wider community and result in a net benefit for Queensland.

Queensland Charter for Local Content

The state has developed the **Queensland Charter for Local Content** which provides local firms with full, fair and reasonable opportunities to tender for major Queensland Government projects and procurements. To support the delivery of the government's local content objectives, the government purchases specialist local content and procurement services from the Industry Capability Network (ICN), a division of QMI Solutions Limited. These services contribute to business and employment growth and foster innovation by identifying procurement opportunities for local industry.

Advancing Small Business Queensland Strategy

The **Advancing Small Business Queensland Strategy** 2016–2020, released in 2016, will deliver more innovative and internationally competitive small businesses that contribute to the state's economic development.

This strategy will support businesses transitioning to advanced manufacturing.

Advancing education: An action plan for education in Queensland

Advancing education: An action plan for education in Queensland includes The Schools of the future STEM Strategy for Queensland state schools and #codingcounts: A plan for coding and robotics in Queensland state schools. The action plan promotes fast-tracking the digital technologies curriculum including coding and robotics. Skills in these areas will underpin the future growth of the advanced manufacturing sector.

21st century advanced manufacturing competitiveness has fully converged the digital and physical worlds where advanced hardware combined with advanced software, sensors and massive amounts of data and analytics results in smarter products, processes and more closely connected customers, suppliers and manufacturers.[25]

Opportunities for Queensland

Queensland is the place for innovation, enterprise and industry. With a strong and diverse economy, Queensland has all the competitive advantages to make it the best location to invest and grow your business.

The Queensland Government is unashamedly pro-business with a stable and supportive policy and regulatory regime. Queensland offers the lowest payroll tax rate in Australia, has competitive commercial and industrial property costs, and low workers' compensation premiums.

With an abundance of natural resources, the state has ready access to raw materials supported by comprehensive transport networks and infrastructure. Queensland's skilled workforce is equipped to sustain emerging industries and the support of world-class universities and training institutes will ensure the supply of future workforce needs. Additionally, Queensland boasts an unrivalled proximity to the high-growth markets of the Asia-Pacific, and is home to an enviable lifestyle with a competitive cost of living.

These benefits create endless opportunities across a range of sectors making Queensland the future of Australian business.

In accelerating the shift to advanced manufacturing over the next decade, the state will capitalise on its competitive advantage to realise significant opportunities. This shift will be underpinned by the technological advances in the state's world class research universities and institutes.

Areas of competitive strength and opportunity for Queensland in advanced manufacturing include: aerospace; automotive and transport; biomedical and life sciences; defence; food and beverage processing; industrial biotechnology and bioproducts; mining equipment, technology and services; precision agriculture; and renewable energy. The Queensland Government is developing sector-specific roadmaps in a number of these areas. The Advanced Manufacturing 10-Year Roadmap and Action Plan will support these roadmaps and areas of existing and emerging opportunity for the state.

Aerospace

In 2014, the US aviation consultancy Team SAI forecast that the aerospace maintenance, repair and overhaul market in the Asia-Pacific would grow at a 5% rate between 2014 and 2024.[26] This growth should create a demand for Queensland's significant aerospace precision manufacturing expertise, brazing and heat treatment for avionics and components and large-scale super alloy casting for jet engines.

Automotive and transport

In the year ending June 2014, anecdotal national industry employment estimates from Auto Skills Australia, indicated that employment in Queensland's motor vehicle and parts manufacturing sector was 7,550 people and the number of businesses at the end of June 2013 was 695.[27] In addition to its traditional strengths in heavy vehicle, truck and bus manufacturing, there are opportunities for Queensland to build on its significant dominance in the manufacture of components for four wheel drive and high performance vehicles to develop aftermarket products required for domestic and export markets.

The state is also a leader in developing intelligent transport systems that will be integral to the broad scale introduction of connected and autonomous vehicles (and the road safety and efficiency benefits these vehicles will produce), creating opportunities for innovative businesses in Queensland in the medium term.

Biomedical and life sciences

Building on the state's recognised expertise and capacity in biotechnology and nanotechnology, Queensland's businesses will be well equipped to capitalise on the growing demand for personalised medical devices, particularly for the state's growing aged population, and the assistive technologies to support the infirmed, elderly and disabled with the activities of daily living. There will also be a demand for dental innovation where Queensland has competitive strengths. Queensland is also well placed to capitalise on export opportunities in areas of competitive strength such as the manufacture of scientific instruments (largely medical) and medicinal and pharmaceutical products—areas that experienced the largest increase in real exports (nationally) from 2002–2012.[28]

Defence

Australia is growing its defence sector in response to the changed security environment. Consequently, the increased investment in this sector is creating opportunities for advanced manufacturing in Queensland in areas of significant capability. These include heavy vehicle manufacturing, fibre-reinforced composites and metal-composite hybrid materials development for lightweighting structures and components.

Opportunities also exist for Queensland businesses with capabilities in the manufacture of technologically superior microwave modules and systems for next generation broadband communications at frequencies from L-band to Ka-band, the development of covert and tactical body armour and other ballistic protection for soldier systems and bulk liquid and fuel handling equipment manufacturing.

Queensland businesses and research institutes have significant expertise in sensor manufacturing, microelectronics and advanced materials. These businesses are poised to benefit from funding to be allocated from Australia's Defence Department's Next Generation Technologies Fund (1 July 2016) that is funding nine technology areas three of which are autonomous systems, multidisciplinary material sciences and advanced sensors.[29]

Food and beverage processing

The Asia-Pacific's strong and growing middle class demand for safe, clean and green food together with the state's close proximity to the rapidly growing region creates opportunities for Queensland's food processing sector. The state is recognised for its high quality food and safety standards and value-adding (through manufacturing technologies and processes) to product development, such as ready-to-eat meals. Upstream processing opportunities in agriculture also exist for the production of healthy foods and nutraceuticals which are favoured by the Asian market.

Industrial biotechnology and bioproducts

The development of the industrial biotechnology and bioproducts sector is a priority for the Queensland Government. This sector will focus on the manufacture of products from sustainable organic and/or waste resources into a diverse range of bioproducts such as sustainable chemicals, fuels, synthetic rubber, cosmetics, detergents and textiles. Innovative scientific and industrial technologies create bioproducts which are renewable and provide environmentally beneficial alternatives to existing conventional chemical and fossil fuel refining processes.

Mining equipment, technology and services

Building on world leading innovation in automation for the mining industry, Queensland has significant expertise in boosting safety through automation, meeting industrial standards and regulations, and easing workflow operation. There will be an increasing demand for this expertise as automation becomes more prevalent in the mining sector. Queensland's internationally recognised expertise in the manufacture of specialised mining and mineral processing equipment should deliver significant economic returns to the state over the long term.

Precision agriculture

The growing demand for smart farming that includes precision agriculture (through robotics and automative technologies contributing to more efficient agricultural practices) and telemetry devices (needed to operate farming enterprises remotely)[30] will create robust opportunities for businesses within Queensland's highly productive agricultural industry. There are also opportunities in the agricultural sector for the design and manufacture of biodegradable starch-based plastics and composites through cleaner processes and easier recycling.

Renewable energy

The Queensland Government is committed to growing large-scale solar in Queensland through the Solar 150 program—Queensland's large-scale solar investment program which aims to support up to 120 megawatts of solar power generation in Queensland—to drive significant growth in renewable energy investment. This initiative may provide an opportunity for Queensland's advanced manufacturing sector to test and deploy innovations such as composites for wind turbines, cooling tower design for solar thermal generators, as well as the next generation materials for solar panels and batteries.

Sunny Queen Meal Solutions launched in June 2015, operates from a dedicated manufacturing facility in Carole Park Brisbane. The manufacturing facility measures 4000 square metres and is an integrated food manufacturing, storage and distribution hub, producing a range of ready-to-eat egg products. There is currently 105 staff employed by the company at the new operation.

Sunny Queen Meal Solutions provides innovative egg products, for use in commercial kitchens in the hospitality industry, schools, mining companies, airlines, and by health care providers. Products include pre-prepared meals such as omelettes, scrambled egg mixes, egg bakes and poached eggs. The meals are made fresh and then either pasteurised or fully cooked before being snap frozen.

The Sunny Queen Meal Solutions' R&D and culinary team includes food technologists, chefs, engineers and global food trend analysts who closely monitor taste trends and new ways of improving performance and efficiencies. This assists Sunny Queen Meal Solutions to deliver innovative safe food solutions, increase productivity and boost growth with a wide variety of products. Sunny Queen began exporting to selected Asian markets in 2014.

Since 2006, the **University of Queensland's (UQ) Centre for Advanced Materials Processing and Manufacturing (AMPAM)** researchers have been working closely with **William A. Cook Australia (COOK)** which is a medical device manufacturer based in Brisbane that employs over 400 people in Queensland and exported over $120 million worth of Queensland manufactured medical devices to over 135 countries in 2015. COOK's operations in Queensland represent the largest manufacturing facility for fully customised, minimally invasive aortic stent grafts in the world.

In May 2016 AMPAM partnered with COOK Medical, Heat Treatment Australia, QMI Solutions, Bosch, University of the Sunshine Coast and Advanced Materials Solutions Pty Ltd in being awarded a $4.9 million (over five years) Australian Research Council Industry Transformation Research Hub for Advanced Manufacturing of Personalised Medical Devices. This represents a significant expansion of manufacturing research and supply chain development activities in Queensland.

Artificial leg with mobile connection by student Troy Baverstock

Griffith University's diverse expertise in advanced manufacturing will be brought together over the next few years in the **Advanced Design and Manufacturing (ADaM) Institute**—a state-of-the-art equipment, knowledge and research hub to be located at the Gold Coast Health and Knowledge Precinct (subject to development approvals) following the 2018 Commonwealth Games. The innovative health-based businesses planned to be located alongside the institute will create opportunities for the state's advanced manufacturing sector.

limbU is a 3D printed device that enhances traditional prosthetic limbs by transforming their utilitarian appearance and function into a smart, bluetooth-connected wearable device. limbU contains a personal activity tracker, audio system, phone charger and medical diagnostic tool with interchangeable aesthetic covers and user controllable lighting to complement modern life.

On 6 October 2015, **Siemens**, **Australia's Defence Science and Technology Group** and the **Queensland University of Technology (QUT)** signed an historic agreement to advance the use of high temperature superconducting (HTS) technologies in Australia. Under this agreement HTS technologies capable of saving energy and increasing capabilities will be introduced to naval fleets. HTS technologies have broad application to a range of industries and will contribute to increased productivity in these industries. The five-year agreement has an initial investment of approximately AUD$2.5 million.[31]

Patheon, a pharmaceutical manufacturing and development company that currently employs in excess of 100 staff (more than 85% with a tertiary qualification) at their award winning state-of-the-art* facility adjacent to the Translational Research Institute at Brisbane's Princess Alexandra Hospital, has become a major driver of the emerging biologics** sector of the local pharmaceutical industry. Patheon does not manufacture active pharmaceutical ingredients (tablets) only biologics—predominantly humanised IgGs*** and recombinant proteins.[32]

SuperPro is an Australian manufacturer of automotive polyurethane bushings and suspension parts, based in Brisbane, Queensland. Built on a foundation of knowing suspension and wheel alignment concepts, SuperPro has been a market leader globally for 30 years.

The driving force within the organisation has been to innovate and push the boundaries of what is possible. By utilising modern design techniques, rapid prototyping using 3D printing and Finite Element Analysis, SuperPro can respond in a much shorter time frame and bring quality solutions to market.

With a research and development team based close to the manufacturing facility, testing of new and improved materials and processes is streamlined.

SuperPro is recognised globally for its premium polyurethane product due to the evolution of the material and design capabilities. With a philosophy of constant improvement, SuperPro will continue to grow and develop cutting edge products.

* 2014 International Society for Pharmaceutical Engineers international award for manufacturing facility of the year. ** Biologics includes a growing class of modern complex protein based (predominantly humanised) medicines, produced in living systems, that provide new options for patients with complex diseases, such as breast cancer, metabolic and autoimmune disorders. *** Immunoglobulin Gs.


OF
OVERHEAD
CRANE
TAE
LUCAS
TAE
WARNING
LOCK TURRET TRAVERSE LOCK AND
TRAVEL LOCK BEFORE ALL
STABILIZATION TESTING. GUN
OR TURRET MAY MOVE SUDDENLY
DURING TEST. IF MAIN GUN OR
TURRET MUST BE UNLOCKED,
CLEAR AREA AROUND TANK AND
BREECH OF ALL PERSONNEL
AND EQUIPMENT.

The challenges

Transforming the manufacturing industry will be critical in addressing a range of general economic and industry challenges facing the nation including rising living and energy costs and weak productivity growth while manufacturing centres in Europe, China and the USA are growing stronger.[33]

Additionally, the winding down of the construction and investment phase of the resource sector, the softening of commodity prices and the closure of the passenger motor vehicle manufacturing sector, slated for the end of 2017, will impact significantly on the national and Queensland economy.

Queensland's advanced manufacturing businesses are some of the most innovative businesses in the state. The Australian Bureau of Statistics data, quoted in the 2016 Australia Institute Report, 'Manufacturing (Still) Matters', indicates that manufacturing is the most innovation-intensive sector in the whole economy with $4.8 billion spent on research and development in 2013–14—more than any other sector of the economy.[34] Moreover, almost 5% of manufacturing gross domestic product is put into innovation—four times the economy-wide average and higher than any other sector, including professional and scientific services.[35]

The task ahead will be to assist these businesses identify and prioritise the changes required to maintain their international competitiveness and increase participation in global supply chains, while moving more traditional manufacturers into the advanced manufacturing sector over the next 10 years.

The consultation process underpinning this roadmap identified a number of challenges summarised below which are hampering Queensland manufacturing businesses' efforts to become more innovative and internationally competitive.

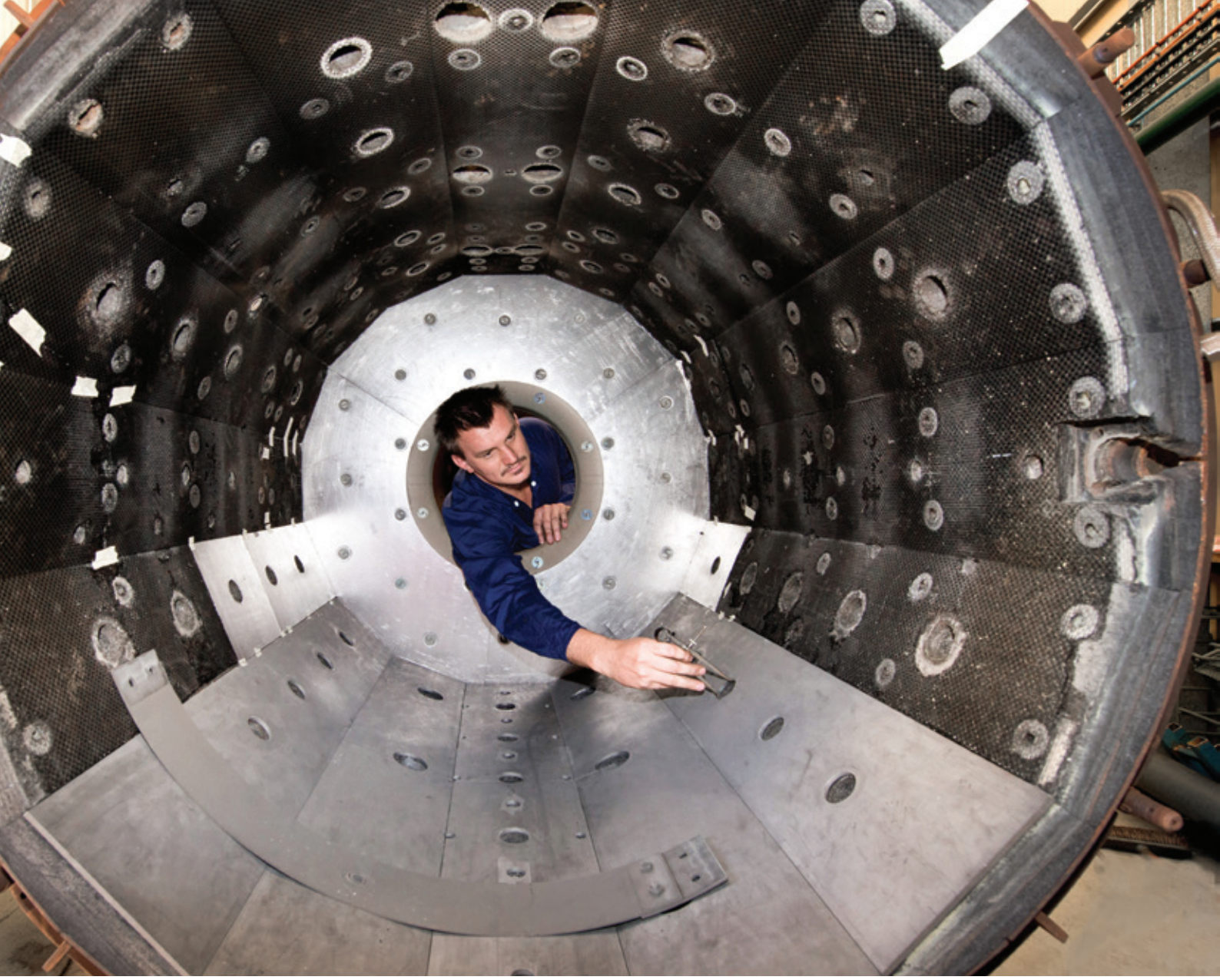
Productivity and international competitiveness

Businesses often do not benchmark performance, pre and post advanced manufacturing technologies investment, against international best practice. This impacts on the businesses' ability to quantify the value of their investment and improve their competitiveness.

The Council of Australian Governments has noted that increasing the skills and qualifications of individual workers is critical to support Australian businesses and drive improvements in the productivity of the economy while fostering greater levels of workforce participation.[36]

Professor Goran Roos, Chairman of the Advanced Manufacturing Council of South Australia has also advised that the success factors for global manufacturing comprise… 'an emphasis on quality and design, high calibre management and workforce skills'.[37]

Within the advanced manufacturing sector, training for the new technical skills requirements including digital expertise, design and coding, needs boosting. A robust industry demand-driven approach to vocational and educational training in these areas would equip the future workforce with the high quality and relevant skills required for an advanced manufacturing sector. The integration



of design graduates into the workforce is also low which limits businesses' capacity for the innovative product and process development required for increased productivity.

Business success, particularly international success, relies on good leadership. These leadership skills need strengthening. Additionally, there is an urgency for businesses to undertake workforce development initiatives including succession planning to address issues associated with the ageing of the traditional manufacturing workforce.

Increasing business participation in global value chains is also required to capitalise on the opportunities in the international economy and drive increased industry and economic growth and productivity.

Rising energy costs and other related input costs are impacting adversely on businesses' productivity and there are some concerns about the negative impact of administering regulations on the sector. The latter will be addressed, in part, through the Queensland Government's Red Tape Reduction Advisory Council that is focusing on red, green and blue tape across at least three industry sectors—one of which is metals manufacturing.

Identify, adopt and adapt innovative technologies and processes

Queensland's manufacturing businesses often require increased:

- awareness of appropriate advanced manufacturing technologies and key enabling technologies (such as photonics, nanotechnology, industrial biotechnology) and their benefits to the business
- knowledge to inform a purchase of technology
- expertise on how to use the technology.

Some businesses display low ICT literacy and find the associated capital and ongoing ICT maintenance can be costly in terms of time and money.[38] More generally, the 2016 Sensis E-Business Report noted that only 19% of the 1000 Australian small and medium sized businesses surveyed had a digital business strategy.[39]

The 2014 report by Australia's Office of the Chief Economist (OCE) on the nation's innovation system noted that collaborative innovation between business and research organisations triples the likelihood of business productivity growth.[40] However, the OCE's 2015 report on the same topic revealed that Australia ranked 26th out of 26 countries for collaboration on innovation between SMEs and research institutions.[41]

Additionally, a 2012 Australian Industry Group National CEO Survey on Business Investment in New Technology found that only 6% of manufacturing businesses nationwide collaborate with government or research institutions to develop new technologies.[42] Consultation undertaken supports the view that there is a lack of collaboration between researchers and industry in the development, adoption and commercialisation of advanced manufacturing technologies in the state.

The need for increased industry and research collaboration and co-location was identified as a major recommendation in a study on advanced manufacturing by the Office of the Queensland Chief Scientist.[43]

Perception and understanding of advanced manufacturing

Communities' perception that the manufacturing (and by extension advanced manufacturing) sector is in decline is devaluing the importance of manufacturing to the economy and thereby reducing the industry's ability to attract new businesses and apprentices into the sector.

As Queensland students need to become more proficient in science, technology, engineering and maths to participate in a highly skilled, agile and innovative advanced manufacturing workforce, the focus on these subjects needs to be encouraged.

Additionally, Queensland's advanced manufacturing expertise and capacity is not widely understood and acknowledged. The state's success and achievements in this sector need stronger promotion and marketing in domestic and international markets.

Queensland Advanced Manufacturing
10-Year Roadmap and Action Plan

1 Increase productivity and international competitiveness	2 Target the adoption and adaptation of innovative technologies and processes	3 Promotion and marketing (domestic and international)

Future actions

Actions under three strategies have been identified through consultation and research. They will capitalise on Queensland's competitive strengths and respond to the advanced manufacturing sector's opportunities and challenges. These actions will deliver an innovative, productive and robust advanced manufacturing sector in the state. These strategies are:

- **increase productivity and international competitiveness**
- **target the adoption and adaptation of innovative technologies and processes**
- **promotion and marketing (domestic and international).**

The actions focus on the transitioning process to advanced manufacturing. Many of the workshops, forums and programs flagged in the actions will be accessible by businesses in the Advance Queensland priority industry sectors.

In implementing the actions, the Queensland Government will adopt a partnership approach with business and other stakeholders to ensure the initiatives are effectively adopted. The IMAG will provide the Queensland Government with strategic advice on the roadmap going forward and oversee its implementation. These actions will be rolled out over a number of years.

Following is a snapshot of the actions to assist businesses respond to the challenges and opportunities in the transition to advanced manufacturing. A more detailed summary of actions is provided on pages 26 and 27.

If the manufacturing industry is to become more sophisticated and globally connected it needs to grow and transform from broad based manufacturing to advanced manufacturing where businesses increasingly adopt world-best technologies, systems, practices and processes to produce low-volume, high-value customised products in a sustainable manner.


CHALLENGES/OPPORTUNITIES
ACTIONS
STRATEGIES
Limited international benchmarking
Advanced Manufacturing Benchmarking Program
Low level of business model development and management skills
Low participation in global value chains
Rising energy costs
Boosting Business Productivity Program
Strategy 1
Low focus on design practices
Advanced Manufacturing Design Program
Limited training in new technical skills
Limited workforce succession planning
Advanced Manufacturing Skills, Training and Workforce Development Strategy
Opportunities to encourage and increase young people's participation in converting ideas to manufactured products
Establish and expand Hacker/Maker spaces
Opportunities in the health, disability and aged sectors and automotive sector
Delivering specific activities in areas of existing and emerging opportunities
Difficulties in identifying and absorbing new technologies
Lack of digital capabilities and strategies
Advanced Manufacturing Transition Program
Strategy 2
Low level of research and industry collaboration and co-location
Leveraging Australian Government initiatives
Low international profile
Low profile in the community
Difficulty attracting young entrants
Low uptake of STEM by primary and secondary students
Promotion and marketing (domestic and international)
Strategy 3

Advanced Manufacturing 10-Year Roadmap and Action Plan

Vision

Capitalising on its competitive strengths in existing and emerging sectors, Queensland will be a recognised leader, nationally and internationally, by 2026 for its advanced manufacturing technologies, products, systems and services that are innovative, sustainable, and embedded in local and global supply chains.

Opportunities

- Aerospace
- Automotive and transport
- Biomedical and life sciences
- Defence
- Food and beverage processing
- Industrial biotechnology and bioproducts
- Mining equipment, technology and services
- Precision agriculture
- Renewable energy

Challenges

- Productivity and international competitiveness
- Identify, adopt and adapt innovative technologies and processes
- Perception and understanding of advanced manufacturing

Strategy 1

Increase productivity and international competitiveness

Actions

- Develop an **Advanced Manufacturing Benchmarking Program** that assists businesses measure their performance and practices and subsequently informs their choice of a suite of business improvement measures offered by the Department of State Development or other agencies, to help them grow and innovate
- Deliver in partnership with key stakeholders, a **Boosting Business Productivity Program** comprising a series of workshops, forums and specific programs across the state to strengthen business model development and management skills, increase participation in global value chains and address rising energy and other related input costs. These include:
  - new business model development (including servitisation) and advanced business management skills
  - the journey to advanced manufacturing
  - supplying into global value chains
  - sustainable manufacturing processes
  - B2B network development for dissemination of information and advice on areas including best practice processes and accessing global supply chains
- Work with Queensland industry, researchers and other relevant organisations to develop an **Advanced Manufacturing Design Program** that will increase businesses' international competitiveness by accelerating the incorporation of design principles and practices in manufactured products
- Partner with industry to develop an **Advanced Manufacturing Skills, Training and Workforce Development Strategy** to prepare businesses for the new technical and workplace requirements. The Strategy will:
  - identify the new skills required in advanced manufacturing
  - explore alternate training approaches for workers to improve their workplace readiness
  - examine options to increase industry's mentoring role including using the knowledge and experience of senior and retired business people
  - incorporate a stronger focus on training and education in design for application in additive manufacturing and other processes and explore methods for integrating design graduates into the workforce
  - review workforce planning and development issues and opportunities and develop workforce succession planning modules.

Strategy 2

Target the adoption and adaptation of innovative technologies and processes

Actions

- Support the establishment and expansion of Hacker/Maker spaces and other similar initiatives across Queensland that will provide community spaces with industrial tools and equipment for designing, coding, sensor use and low cost prototyping to encourage and increase young people's participation in the conversion of ideas to manufacturing products
- Support activities in areas of existing and emerging opportunity including:
  - Support the establishment of an Australian Automotive Innovation Lab (AutoLab), subject to a feasibility study, to support the Queensland automotive aftermarket sector become more globally competitive
  - Capitalise on the opportunities to provide assistive technologies to clients of the NDIS and the National Injury Insurance Scheme, and products and services to the health and aged sectors
- Develop an **Advanced Manufacturing Transition Package (AMTP)**, supported by a network of 'best practice' advanced manufacturing businesses, that includes a series of workshops and forums, to be delivered across the state to develop digital business capability and strategies and assist in new technology identification and absorption
- Leverage Australian Government support for initiatives including CSIRO's Future Manufacturing National Research Flagship, the Advanced Manufacturing Growth Centre, the Innovative Manufacturing Cooperative Research Centre and support the establishment of a Techshop to strengthen industry and research partnerships and co-location, and boost the competitiveness, productivity and innovative capacity of Queensland's advanced manufacturing sector.

Strategy 3

Promotion and marketing (domestic and international)

Actions

- Promote Queensland's advanced manufacturing technologies and expertise in selected overseas markets through targeted trade missions and business matching and showcasing Queensland capabilities to international delegations
- Identify and grow new markets for Queensland's advanced manufacturing businesses
- Facilitate increased foreign investment in advanced manufacturing and pursue targeted international companies focussing strongly on advanced manufacturing to relocate to the state
- Market Queensland's advanced manufacturing achievements through a range of measures including attendance at leading domestic trade shows and case studies
- Organise targeted events to promote opportunities in advanced manufacturing
- Promote future career opportunities in advanced manufacturing across the education sector and encourage the focus on science, technology, engineering and maths in schools to prepare young people for careers in advanced manufacturing.

Appendix A

List of key Queensland research institutes and universities—advanced manufacturing

- **ARC for Aerospace Automation** (QUT, CSIRO and Queensland Government)
- **ARC Centre of Excellence for Robotic Vision** (QUT – headquarters)
- **Australian Institute for Bioengineering and Nanotechnology** (UQ)
- **Australian National Fabrication Facility** (nodes at UQ and GU)
- **Automotive Australia 2020 CRC** (QUT – partner)
- **Centre for Advanced Materials Processing and Manufacturing** (UQ)
- **Centre for Future Materials** (USQ)
- **Centre for Future Timber Structures** (UQ)
- **Centre for High Performance Polymers** (UQ)
- **CRC for Polymers** (QUT, UQ, GU – participants)
- **Defence Materials Technology Centre** (UQ, QUT – participants)
- **Dow Centre for Sustainable Engineering Innovation** (UQ)
- **Innovative Manufacturing CRC** (JCU, QUT, GU)
- **Institute of Health and Biomedical Innovation** (QUT)
- **Medical Engineering Research Facility** (QUT)
- **National Biologics Facility** (UQ – node)
- **National Centre for Engineering in Agriculture** University of Southern Queensland (USQ)
- **Nihon Superior Centre for the Manufacture of Electronic Materials** (UQ)
- **Queensland Centre for Advanced Technologies** (CSIRO)
- **Railway Manufacturing CRC** (Central Queensland University (CQU), QUT, UQ – partners)
- **The Australian Synchrotron—Australian Research Centre (ARC) Special Research Initiative in Synchrotron Science.** The Queensland node comprises Queensland Government, UQ, QUT, JCU, CQU, USQ and University of Sunshine Coast (USC)
- **The Baosteel-Australia Joint Research and Development Centre** (UQ)
- **Translational Research Institute** (UQ, QUT, Mater Research and Queensland Health)

Examples of areas of technical expertise and capability

- **additive manufacturing techniques** (medical prosthetics and dental implants, building and construction, energy storage solutions)
- **advanced forming technologies** (medical and aerospace)
- **advanced materials** (medical devices, construction and civil engineering, transport, aerospace)
- **automative technologies and robotics** (agriculture and mining)
- **biomanufacturing** (medicine, energy and electronics)
- **electronics manufacture** (aerospace, medical devices, ICT and communications, defence, mining)
- **heavy engineering** (transport)
- **high temperature superconducting technologies** (energy, defence)
- **innovative processing technologies** (food and beverage manufacturing including alcoholic and non-alcoholic beverages)
- **precision tooling and niche machining** (aerospace, medical devices and instruments, mining equipment)
- **technologically superior microwave modules and systems** (next generation broadband communications, defence)

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